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Depleted Uranium Hexafluoride Management Program: Data Compilation for the K-25 Site

in Support of Site-Specific NEPA Requirements for Continued Cylinder Storage and Cylinder Preparation Activities

Environmental Assessment Division
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ACKNOWLEDGMENTS

Much of the information in this report was obtained from the *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (PEIS; U.S. Department of Energy Report DOE/EIS-0269, April 1999). The following individuals contributed to the compilation of the PEIS: Timothy Allison, Georgia Anast, John J. Arnish, Halil Avci, Bruce Biwer, Charles E. Bradley, Jr., James Butler, Young-Soo Chang, Jing-Jy Cheng, David Dolak, Stephen Folga, Marsha Goldberg, Larry J. Gorenflo, Rebecca Haffenden, Scott E. Harlow, Heidi Hartmann, Cathy Huss, Deborah Jilek, Kirk LaGory, Timothy T. Long, Frank Mancino, Janet Manual, Gary Marmer, Fred Monette, Marita Moniger, Bassel K. Nabelssi, Lee Northcutt, John M. Pfingston, Anthony J. Policastro, Elisabeth A. Stull, David Tomasko, John Tschanz, Robert VanLonkhuyzen, Bruce Verhaaren, Konnie L. Wescott, Bruce Wilkins, Gary Williams, and Dimis Wyman.

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NOTATION

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
AQCR	Air Quality Control Region
BEA	U.S. Bureau of Economic Analysis
CAAA	*Clean Air Act Amendments*
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act* of 1980
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EBE	evaluation-basis earthquake
EPA	U.S. Environmental Protection Agency
FFA	Federal Facilities Agreement
HAP	hazardous air pollutant
HC	hydrocarbons
HEPA	high-efficiency particulate air (filter)
LCF	latent cancer fatality
LLMW	low-level mixed waste
LLNL	Lawrence Livermore National Laboratory
LLW	low-level radioactive waste
LMES	Lockheed Martin Energy Systems, Inc.
MCL	maximum contaminant level
MEI	maximally exposed individual
MMES	Martin Marietta Energy Systems, Inc.
MOA	memorandum of agreement
NAAQS	National Ambient Air Quality Standards
NCRP	National Council on Radiation Protection and Measurements
NEPA	*National Environmental Policy Act* of 1969
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl

PEIS	programmatic environmental impact statement
PEL	permissible exposure limit
PM_{10}	particulate matter with a mean diameter of 10 :m or less
RCRA	*Resource Conservation and Recovery Act*
ROD	Record of Decision
ROI	region of influence
SAR	safety analysis report
TDEC	Tennessee Department of Environment and Conservation
TSCA	*Toxic Substances Control Act*
USC	*United States Code*
USEC	United States Enrichment Corporation

Chemicals

AlF_3	aluminum trifluoride
CaF_2	calcium fluoride
CO	carbon monoxide
Fe	iron
HF	hydrogen fluoride
HNO_3	nitric acid
Mg	magnesium
MgF_2	magnesium fluoride
NaOH	sodium hydroxide
NO_x	nitrogen oxides
O_3	ozone
Pb	lead
SO_x	sulfur oxides
TCE	trichloroethylene
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
UO_2	uranium dioxide
UO_2F_2	uranyl fluoride
$UO_2(OH)_2$	uranyl hydroxide
U_3O_8	triuranium octaoxide (uranyl uranate)

UNITS OF MEASURE

EF	degree(s) Fahrenheit	gpm	gallon(s) per minute
Ci	curie(s)	GWh	gigawatt hour(s)
cm	centimeter(s)	ha	hectare(s)
cm^3	cubic centimeter(s)	in.	inch(es)
d	day(s)	kg	kilogram(s)
ft	foot (feet)	km	kilometer(s)
ft^2	square foot (feet)	L	liter(s)
g	gram(s)	lb	pound(s)
gal	gallon(s)	:g	microgram(s)

:m	micrometer(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mg	milligram(s)
min	minute(s)
mrem	millirem(s)
MVa	megavolt-ampere(s)
MW	megawatt(s)
MWh	megawatt hour(s)
pCi	picocurie(s)
ppb	part(s) per billion
ppm	part(s) per million
psia	pound(s) per square inch absolute
rad	radiation absorbed dose(s)
rem	roentgen equivalent man
s	second(s)
scf	standard cubic foot (feet)
ton(s)	short ton(s)
yd^2	square yard(s)
yd^3	cubic yard(s)
yr	year(s)

DEPLETED URANIUM HEXAFLUORIDE MANAGEMENT PROGRAM: DATA COMPILATION FOR THE K-25 SITE

in Support of Site-Specific NEPA Requirements for Continued Cylinder Storage and Cylinder Preparation Activities

Compiled by
H.M. Hartmann

ABSTRACT

This report is a compilation of data and analyses for the K-25 site on the Oak Ridge Reservation, Oak Ridge, Tennessee. The data were collected and the analyses were done in support of the U.S. Department of Energy (DOE) 1999 *Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (DOE/EIS-0269). The report describes the affected environment at the K-25 site and summarizes the potential environmental impacts that could result from continued cylinder storage and preparation of cylinders for shipment at the site. It is probable that the cylinders at the K-25 site will be shipped to another site for conversion. Because conversion and long-term storage of the entire inventory at the K-25 site are highly unlikely, these data are not presented in this report. DOE's preferred alternative is to begin converting the depleted uranium hexafluoride inventory as soon as possible to either uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.

1 INTRODUCTION AND BACKGROUND

This report is a compilation of data and analyses for the K-25 site, which were obtained and conducted to prepare the *Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (U.S. Department of Energy [DOE] 1999a; hereafter referred to as the PEIS). The PEIS examines alternative management strategies for the long-term storage, use, and disposal of the nation's depleted uranium hexafluoride (UF_6) inventory that falls under the responsibility of DOE. This inventory currently amounts to approximately 700,000 metric tons of depleted UF_6, containing about 476,000 metric tons of uranium. It is stored at three sites: the Paducah site in Kentucky, Portsmouth site in Ohio, and East Tennessee Technology Park in Tennessee. (East Tennessee Technology Park is referred to by its original name, the K-25 site, throughout this report.) The inventory is stored in about 57,700 steel cylinders and includes about 11,200 cylinders of material that have been or will be transferred to DOE from the United States Enrichment Corporation (USEC) under two recent memorandums of agreement (MOAs). Approximately 10% of the above inventory is stored at the K-25 site in 4,683 cylinders; no USEC-generated cylinders are stored at the K-25 site.

The PEIS examines six alternative management strategies (also termed "alternatives"). These include a no action alternative (indefinite, continued storage of the depleted UF_6 at the current storage sites) and five action alternatives (long-term storage as UF_6, long-term storage as uranium oxide, use as oxide, use as uranium metal, and disposal). Each of the alternatives would involve some combination of seven activities: continued cylinder storage at the current storage sites, cylinder preparation for shipment, conversion to another chemical form, long-term storage, manufacture and use, disposal, and transportation. This report presents K-25 site-specific data from the PEIS for continued storage and cylinder preparation activities, as well as data on the existing environment and cumulative impacts at the site.

This report documents the information and results of analyses already obtained and conducted for the K-25 site during the preparation of the PEIS, which can serve as a starting point for preparation of site-specific analyses required under the National Environmental Policy Act (NEPA). This report's compilation of data should provide background for and expedite subsequent environmental assessment and procurement tasks needed to implement the strategy selected in the *Record of Decision for Long-Term Management and Use of Depleted Uranium Hexafluoride* (DOE 1999b).

The PEIS presents data on the existing environment at the three current storage sites. The information covers ambient air quality, geology and soil, water resources, biotic resources, public and occupational health and safety, socioeconomics, waste management, cultural resources, and the prevalence of minority and low-income populations. These data are presented in Section 2 of this report specifically for the K-25 site.

All of the strategies examined in the PEIS consider the impacts that could result from the continued storage of cylinders at the three current storage sites for some period of time. In addition, because strategies involving the transportation of the cylinders from their current locations for conversion or long-term consolidated storage would involve the preparation of the cylinders for shipment, the PEIS also reviews the site-specific impacts that could result from cylinder preparation at each of the three sites. The impacts of continued cylinder storage presented in the PEIS are presented in Section 3 of this report specifically for the K-25 site. The impacts of cylinder preparation at the K-25 site are discussed in Section 4. Section 5 of this report presents the results of cumulative impact analyses conducted for the K-25 site as part of the PEIS. A bibliography is provided in Section 6. All references that are called out in this report are included in the bibliography.

Although some site-specific data on the conversion and long-term storage of the entire depleted UF_6 inventory were also developed for the PEIS, these data are not presented in this report because both the conversion and the long-term storage of the entire inventory at the K-25 site are highly unlikely alternatives under an existing consent order. DOE entered into this consent order on managing the depleted UF_6 stored at the K-25 site with the Department of Environment and Conservation of the State of Tennessee in 1999. Under the order, DOE agreed that if it chooses any action alternative as the outcome of the PEIS, it shall, subject to appropriate NEPA review, either remove all known cylinders of depleted UF_6 from the K-25 site or complete the conversion of the cylinder contents by December 31, 2009. Therefore, the movement of any additional inventory from the other current storage sites to the K-25 site for conversion or long-term storage is improbable, and the preliminary PEIS data for these activities at the K-25 site are thus not presented here.

The detailed methodologies used to conduct the environmental impact assessments presented in this report are documented in Appendix C of the PEIS and in various backup reports to the PEIS. It is beyond the scope of this report to provide the detailed descriptions of methods presented in these other reports; they are referenced as necessary.

2 AFFECTED ENVIRONMENT

Depleted UF_6 is currently managed at three locations: the Paducah site near Paducah, Kentucky; the Portsmouth site near Portsmouth, Ohio; and the K-25 site on the Oak Ridge Reservation (ORR) near Oak Ridge, Tennessee. The PEIS and this report distinguish the site (the entire DOE facility) from the gaseous diffusion plant (a facility operated by USEC within the larger site) and from the storage yards (the location of the depleted UF_6 cylinders within the site). This section describes the affected environment at the K-25 site.

The K-25 site is part of ORR, which is located in Anderson and Roane Counties, Tennessee, approximately 25 miles (40 km) west of the city of Knoxville (Figure 2.1). The reservation consists of three major facilities — the K-25 site, Oak Ridge National Laboratory, and the Y-12 plant (Figure 2.2) — and surrounding property. The 1,700-acre (688-ha) K-25 site contains the Oak Ridge Gaseous Diffusion Plant, which has been inactive since 1985. Currently, the primary mission of the K-25 site is environmental restoration and waste management activities (Martin Marietta Energy Systems, Inc. [MMES] 1994b).

Anderson County and the City of Oak Ridge have developed planning documents to control land use. Anderson County's comprehensive plan was created in 1982, and the City of Oak Ridge updated its comprehensive plan in 1988. Roane County has not formally developed or adopted a comprehensive or master plan.

The K-25 site includes more than 300 buildings with a combined floor space of 13 million ft^2 (1.2 million m^2) (MMES 1994b). Site management, in conjunction with DOE's land management policy, is currently pursuing an option to lease a 957-acre (387-ha) parcel of site land to the Community Reuse Organization of East Tennessee. The K-25 parcel, which is located northeast of the core area, would be used as an industrial park, a use that is compatible with current site development plans. ORR has a master plan that is updated every 5 years.

In 1989, ORR was placed on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL), meaning that cleanup requirements mandated by the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) would be met in conducting remediation efforts. Several operable units (groups of similar potentially contaminated units) have been identified at the Y-12 plant, 20 waste area groupings (similar to operable units) have been identified at Oak Ridge National Laboratory, and 15 operable units have been identified at the K-25 site. Hazardous waste and mixed waste management at ORR must also comply with *Resource Conservation and Recovery Act* (RCRA) regulations. The ORR Federal Facilities Agreement (FFA) was developed to integrate CERCLA/RCRA requirements into a single remediation procedure. This discussion of affected environment focuses on conditions and contaminants pertinent to depleted UF_6

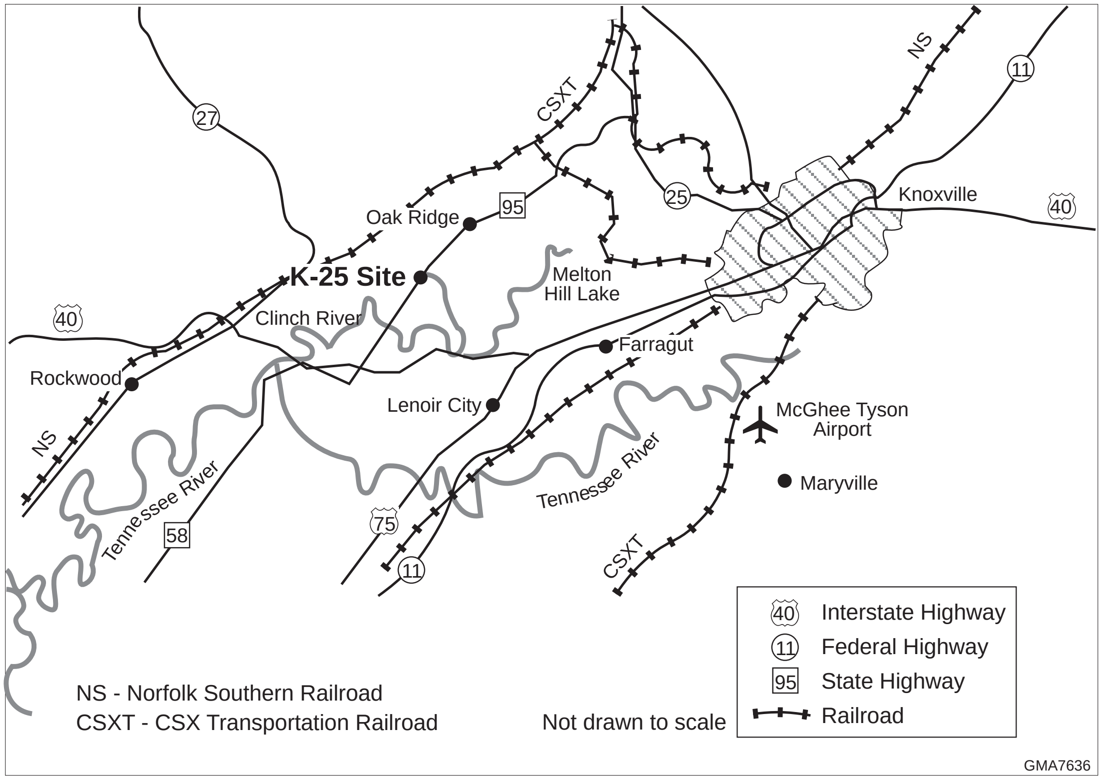

FIGURE 2.1 Regional Map of the K-25 Site Vicinity (Source: Adapted from Argonne National Laboratory [ANL] 1991)

cylinder management. Some K-25 sitewide information from ongoing CERCLA/RCRA investigations is also included to put environmental conditions in the current depleted UF_6 cylinder storage areas into the context of sitewide conditions.

2.1 CYLINDER YARDS

There are 4,683 depleted UF_6 storage cylinders located in three K-25 site cylinder yards (Table 2.1; Figure 2.3). Cylinders are stacked two high to conserve storage yard space. The K-1066-K yard (K-yard) currently contains the most cylinders (2,945); it is constructed of concrete and crushed stone. Because of historically poor drainage conditions in K-yard, all cylinders in K-yard are currently inspected annually. Most of the remaining K-25 site cylinders (1,716) are stored in the K-1066-E yard (E-yard), which is constructed of concrete; the K-1066-L yard (L-yard) contains only 22 cylinders. The E-yard and L-yard cylinders are inspected once every 4 years.

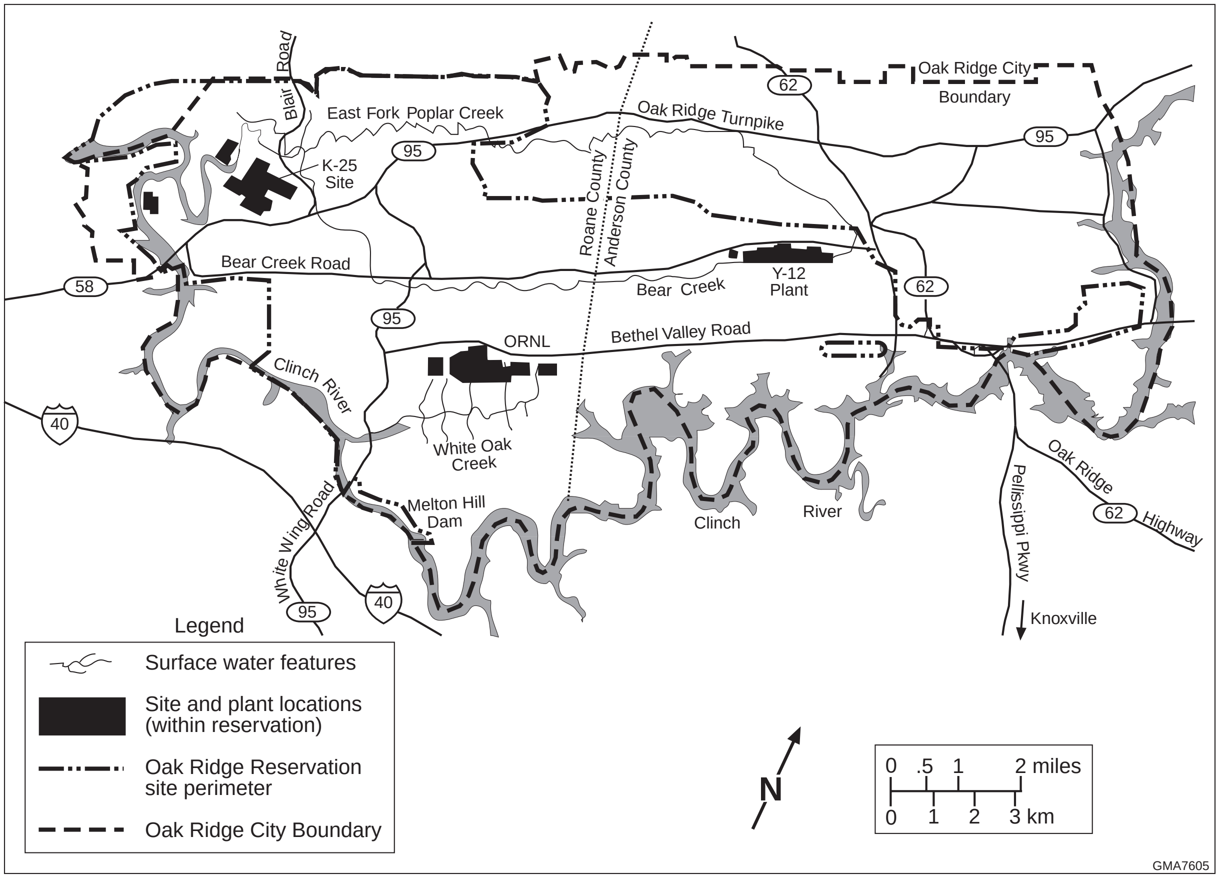

FIGURE 2.2 Map of the Oak Ridge Reservation (Source: MMES 1994b)

TABLE 2.1 Locations of DOE Depleted UF_6 Cylinders at the K-25 Site[a]

Yard	Area (ft^2)	Number of Cylinders
K-1066-K	134,825	2,945
K-1066-E	157,376	1,716
K-1066-L	43,824	22

[a] Locations of cylinders as of May 1996.

Source: Cash (1996).

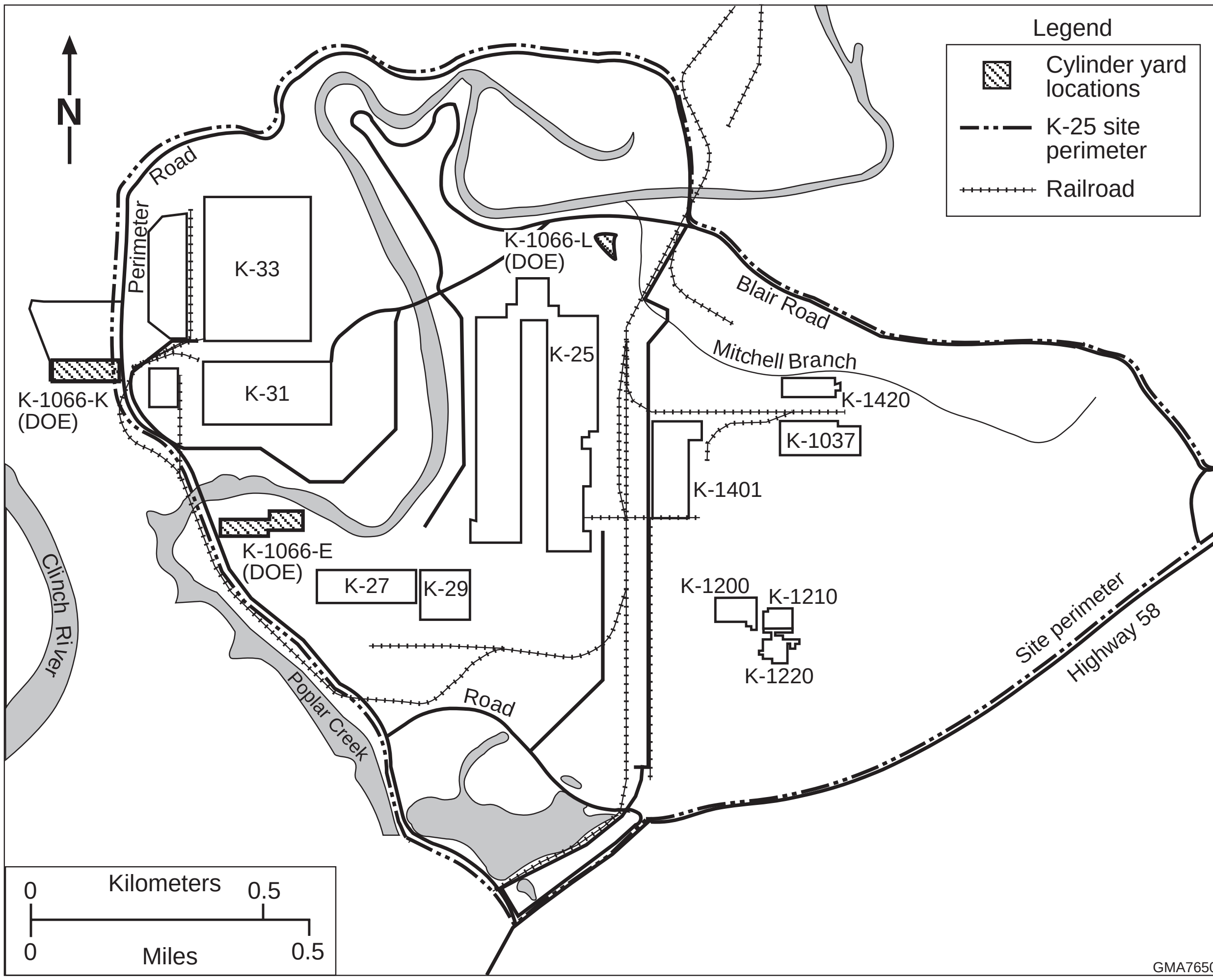

FIGURE 2.3 Locations of Cylinder Yards at the K-25 Site That Are Used to Store DOE Cylinders (Source: Adapted from MMES 1994a and Lockheed Martin Energy Systems, Inc. [LMES] 1996a)

Four breached cylinders were discovered at the K-25 site in early 1992; two were located in K-yard and two in E-yard. The cause of the K-yard breaches seemed to be external corrosion from poor storage conditions, whereas the cause of the E-yard breaches could be attributed to handling damage and subsequent corrosion at the damaged points. The hole diameters for three of the breached cylinders ranged from 2 to 10 in. (5 to 25 cm); the dimensions of the fourth breach, the largest (an E-yard breached cylinder), were approximately 17 × 12 in. (43 × 30 cm). The four breached cylinders have been patched to restore their integrity, segregated from the other cylinders in K- and E-yards, and placed under temporary awnings. Because equipment to weigh the cylinders was not available at the K-25 site, the extent of material loss from these cylinders could not be determined.

One additional cylinder breach occurred in 1998 during the course of cylinder maintenance operations (i.e., surface preparation and painting). The breach was patched to prevent material loss from the cylinder.

2.2 SITE INFRASTRUCTURE

The K-25 site is located in an area with a well-established transportation network. The site is near two interstate highways, several U.S. and state highways, two major rail lines, and a regional airport (Figure 2.1).

Water is supplied to the K-25 site through a pumping station on the Clinch River. The water is treated and stored in two storage tanks. This system, with a capacity of 4 million gal/d (15 million L/d), also provides water to the Transportation Safeguards Facility and the K-25 site. Average water consumption for these three facilities in 1994 was 2 million gal/d (8 million L/d) (DOE 1995a).

Electric power is supplied by the Tennessee Valley Authority. The distribution of power is managed through the K-25 Power Operations Department. The average demand for electricity by all of the Oak Ridge DOE facilities, including the K-25 site, is approximately 100 MVa. The maximum capacity of the system is 920 MVa (DOE 1995a). Natural gas is supplied by the East Tennessee Natural Gas Company; the current daily capacity of 7,600 decatherms is capable of being increased, if necessary. The average daily usage in 1994 was 3,600 decatherms (DOE 1995a).

2.3 AMBIENT AIR QUALITY AND AIRBORNE EMISSIONS

The affected environment for air quality at the K-25 site was generally considered to be the EPA-defined Air Quality Control Region (AQCR). The EPA has designated the K-25 site as being in the Eastern Tennessee-Southwestern Virginia Interstate AQCR in EPA Region 4. The EPA classifies this AQCR as an attainment area for all six National Ambient Air Quality Standards (NAAQS) criteria pollutants: carbon monoxide (CO), sulfur oxides (SO_x), particulate matter (PM_{10}, particles with a mean diameter of 10 μm or less), ozone (O_3), nitrogen oxides (NO_x), and lead (Pb). An attainment area for a criteria pollutant is an area that has an ambient air concentration of the pollutant below the corresponding standard.

The State of Tennessee has adopted NAAQS, which are presented in Table 2.2. In addition to the standards for criteria pollutants, the Tennessee Department of Environment and Conservation (TDEC) has adopted regulations to provide guidance for evaluating hazardous air pollutants (HAPs) and air toxics that specify permissible short-term and long-term concentrations of various contaminants ("Hazardous Air Contaminants," *Air Pollution Control Regulations*, Chapter 11). The

TABLE 2.2 Tennessee Ambient Air Quality Standards

	Tennessee Standard[a]	
Pollutant	Primary	Secondary
Carbon monoxide (CO)		
1-hour average	35.0 ppm[b]	35.0 ppm
8-hour average	9.0 ppm	9.0 ppm
Sulfur oxides (SO_x)		
3-hour average	–[c]	0.50 ppm
24-hour average	0.14 ppm	–
Annual arithmetic mean	0.03 ppm	–
Particulate matter (PM_{10})		
24-hour	150 : g/m^3	150 : g/m^3
Annual geometric mean	50 : g/m^3	50 : g/m^3
Ozone (O_3)		
1-hour average	0.12 ppm	0.12 ppm
Nitrogen oxides (NO_x)		
Annual arithmetic mean	0.05 ppm	0.05 ppm
Lead (Pb)		
Quarterly average	1.5 : g/m^3	1.5 : g/m^3
Gaseous fluorides (as HF)[d]		
12-hour average	4.5 ppb[b]	4.5 ppb
24-hour average	3.5 ppb	3.5 ppb
7-day average	2.0 ppb	2.0 ppb
30-day average	1.5 ppb	1.5 ppb

[a] Annual standards are never to be exceeded; short-term standards are not to be exceeded more than once per year, unless noted.

[b] ppm = parts per million, ppb = parts per billion.

[c] A hyphen (–) indicates no standard is available for this averaging period.

[d] HF = hydrogen fluoride.

Source: DOE (1996a).

TDEC list is the same as the 189 HAPs listed in Section 112(b) of the *Clean Air Act Amendments* (CAAA) *(United States Code*, Title 42, Parts 7401-7626 [42 USC Parts 7401-7626]). Emission standards for these HAPs are established in the National Emission Standards for Hazardous Air Pollutants (NESHAP) (*Code of Federal Regulations*, Title 40, Part 61 [40 CFR Part 61]).

Ambient air quality is monitored in Anderson and Roane Counties by the Tennessee Division of Air Pollution Control. During 1992, no violations were recorded at the ORR ozone monitor or in nearby Nancy's Grove.

Although uranium enrichment activities at K-25 were discontinued in 1987, ambient air monitoring for uranium, PM_{10}, and several metals has continued at six on-site and off-site locations, with samples collected weekly; fluoride monitoring has been discontinued. As of 1996, monitoring was discontinued at four of the locations after review and concurrence by DOE and the Tennessee Department of Environmental Conservation (LMES 1997b).

For the period 1994 through 1996, the maximum annual average concentration of uranium for the six monitoring locations was 0.00039 $\mu g/m^3$ at Station K2 (LMES 1995a, 1996b, 1997b). The maximum annual average PM_{10} concentration for the same time period was 24.3 $\mu g/m^3$ (40% of the Tennessee and national primary and secondary standards); the maximum quarterly lead concentration was 0.0076 $\mu g/m^3$ (0.5% of the Tennessee and national primary and secondary standards) (LMES 1995a, 1996b, 1997b).

Steam plant emissions have accounted for most of the criteria pollutant emissions at the K-25 site (LMES 1995a). In 1994, all estimated emissions were less than the allowable ones. The K-25 site also contains a Toxic Substances Control Act (TSCA) incinerator. Emissions from the incinerator are controlled by extensive exhaust-gas treatment. Estimated emissions from the incinerator are significantly less than the permitted allowable emissions.

2.4 GEOLOGY AND SOIL

2.4.1 Topography, Structure, and Seismic Risk

The topography of the K-25 site is varied; the maximum change in elevation across the site is about 420 ft (130 m). The site is underlain by sedimentary rocks composed of limestone and dolomite. Sinkholes, large springs, and other karst features can occur in the limestone formations adjacent to the site (DOE 1995a).

The most important structural feature near the site is a system of three faults: the Whiteoak Mountain Fault, which runs through the southeastern corner of K-25; the Kingston Fault, a parallel fault that occurs north of Poplar Creek; and the Copper Creek Fault, located in Melton Valley. A branch of the Whiteoak Mountain Fault originates just south of the site and runs due north through its center. None of these faults appear to have any topographic expression, and it is assumed that displacement took place prior to the development of the current surface of erosion (DOE 1979). Because no surface movement has occurred along these faults for more than 35,000 years and there has been no movement of a recurring nature within the past 500,000 years, the faults are not considered to be capable. Therefore, the evaluation-basis earthquake (EBE) for this site was designated by DOE to have a return period of 1,000 years.

The seismic hazards at the K-25 site have been analyzed and documented in a safety analysis report (SAR) completed in March 1997 (see Sections 1.5 and 3.4 in LMES 1997c). The results presented in the SAR indicate that continued storage of depleted UF_6 cylinders at the K-25 site is safe. For this report and the PEIS, the analysis of earthquake-initiated accidents at the K-25 site were based on the analyses and results provided in the SAR (LMES 1997c). A spectrum of accidents was considered, ranging from those having a high probability of occurrence but low consequences to those having high consequences but a low probability of occurrence. Natural phenomena accidents including earthquakes, floods, and tornadoes were among the accidents considered. For K-25, an earthquake that has a 1,000-year return period would have a horizontal top-of-soil acceleration of 0.2 times the acceleration of gravity. Such an earthquake could occur with equal probability any time during the 1,000-year period. For these conditions, slope stability and soil liquefaction (loss of shear strength) would not be problems, and rocking and rolling-out of cylinders would not occur for single or multiple-stacked cylinders (LMES 1997c).

2.4.2 Soil

Soil and groundwater data have been collected to determine whether contamination is associated with the K-25 cylinder yards (DOE 1994a). Substances in soil possibly associated with cylinder management activities are uranium and fluoride compounds, which could be released to soil if breached cylinders or faulty valves were present. In 1991, 122 systematic soil samples were collected at the K-yard; these samples had maximum concentrations of 0.14 mg/kg uranium-235 and 13 mg/kg uranium-238. Soil samples collected in March 1992 at the K-yard had a maximum uranium concentration of 36 ± 2 mg/kg.

In 1994, 200 systematic and 28 biased soil samples were collected in areas surrounding the cylinder yards; the maximum concentrations detected in these samples were 0.83 mg/kg uranium-235 at K-1066-F yard (F-yard) and 75 mg/kg uranium-238 at E-yard. Groundwater concentrations of total uranium (measured as gross alpha and gross beta) for upgradient and downgradient wells have indicated that although some elevated levels of uranium have been detected in cylinder yard soil, no migration to groundwater has occurred (DOE 1994a). The cause of the isolated elevated uranium-238 level in soil was not identified.

Soil samples collected as part of general site monitoring at K-25 and the immediate surrounding area in 1994 had the following maximum concentrations: uranium, 6.7 mg/kg; Aroclor 1254 (a polychlorinated biphenyl [PCB]), 0.16 mg/kg; cadmium, 0.34 mg/kg; mercury, 0.15 mg/kg; and nickel, 33 mg/kg (LMES 1996a). Fluoride was not analyzed in the soil samples, but it is naturally occurring and of low toxicity. Concentrations of uranium in 1995 and 1996 soil monitoring were lower (LMES 1996b, 1997b).

As part of ongoing CERCLA/RCRA investigations for the K-25 site, several areas of soil have been identified as contaminated with radionuclides and/or chemicals. However, this contamination is not associated with the depleted UF_6 cylinder yards, and remediation is being implemented as a part of ongoing CERCLA/RCRA activities at the site.

2.5 WATER RESOURCES

The affected environment for water resources consists of surface water within and in the vicinity of the site boundary and groundwater beneath the site. Analyses of surface water, stream sediment, and groundwater samples has indicated the presence of some contamination resulting from previous gaseous diffusion plant operations. Although several contaminants are present in the water, only small amounts of uranium and fluoride compounds are related to releases from the cylinders.

2.5.1 Surface Water

The K-25 site is located near the confluence of the Clinch River (a tributary of the Tennessee River) and Poplar Creek (Figure 2.4). There are effluent discharge points on both Poplar Creek and the Clinch River and two water withdrawal points on the Clinch River (DOE 1979).

Because of the presence of the Melton Hill and Watts Bar Dams, the hydrology of the Clinch River-Poplar Creek system near K-25 is very complex. In the vicinity of K-25, most of the facilities are free of flood hazards for both the 100-year and 500-year maximum probable floods in Poplar Creek (Rothschild et al. 1984).

As of 1996, surface water monitoring at K-25 has been conducted at five locations (LMES 1997b). The K-1710 sampling location provides information on surface water conditions upstream of K-25. Station K-716 is downstream of most of the K-25 operations and provides information on the cumulative effects of K-25 operations. The remaining sampling locations are at points where drainage in the major surface water basins converge before discharging to Poplar Creek.

Samples from the K-25 site are analyzed monthly for radionuclides; quarterly samples are collected and analyzed for general water quality parameters, selected metals, and organic compounds

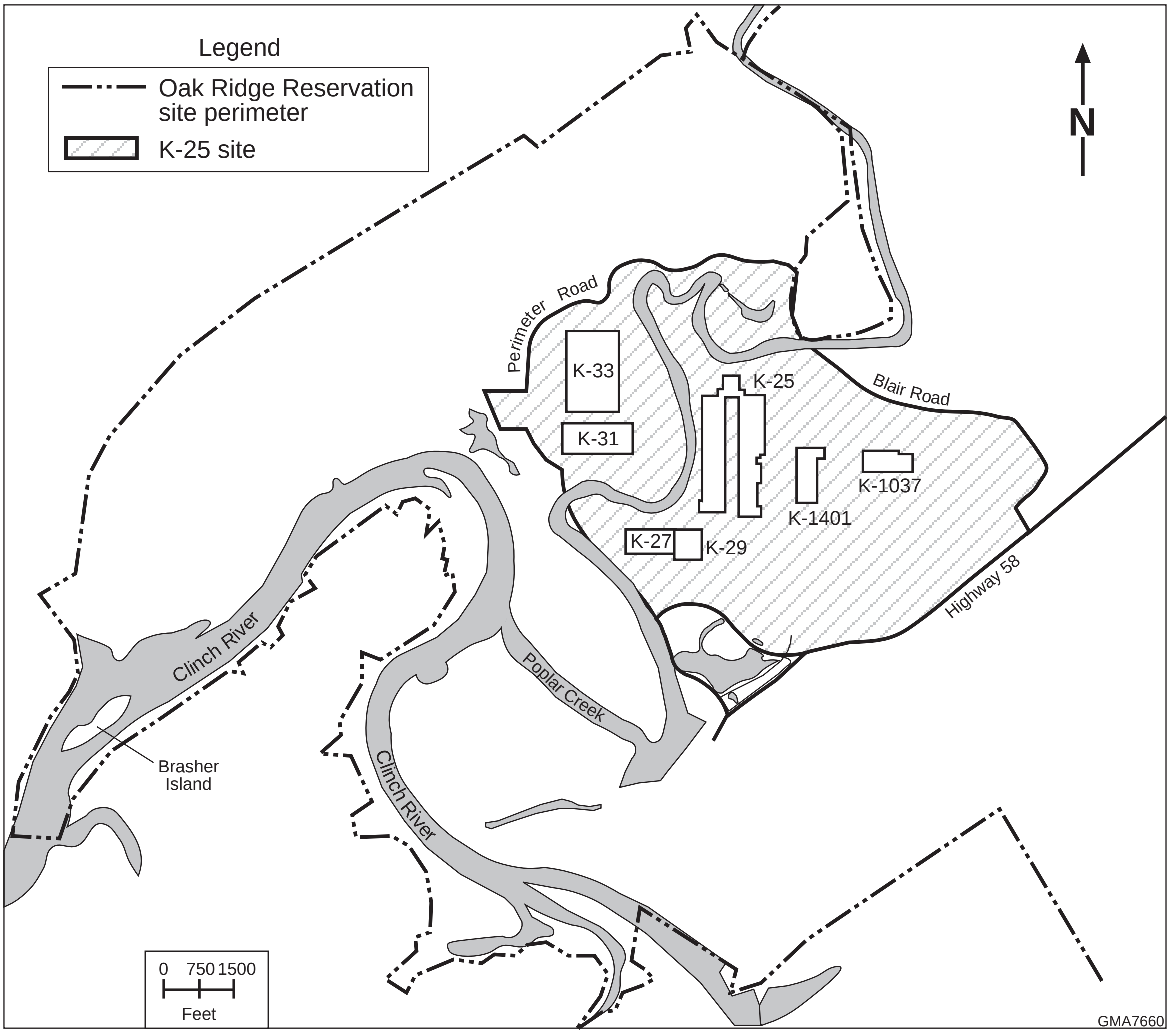

FIGURE 2.4 Locations of Surface Water Bodies near the K-25 Site

(LMES 1997b). Uranium levels have been considerably below permitted levels based on radiological standards. In most instances, results for nonradiological parameters are considerably below their applicable Tennessee water quality standards. In 1994, zinc, which occurs naturally in the soils of the area, was detected just above the limit in one sample from the K-1700 sampling location (LMES 1995a). Lead, nickel, and mercury were occasionally detected but always at low concentrations. In general, analytical results for samples collected upstream of K-25 are chemically similar to those collected downstream of the site.

Sediment sampling has also been performed at points that coincide with the K-25 water sampling locations. These samples were analyzed for uranium and other parameters. For 1994, the following maximum concentrations were measured: uranium, 43 :g/g; mercury, 6 :g/g; nickel, 89 :g/g; and Aroclor 1254, 10 :g/g (LMES 1996a).

2.5.2 Groundwater

Groundwater in the vicinity of the K-25 site occurs in a surficial aquifer and in bedrock aquifers. The surficial aquifer is made up of man-made fill, alluvium, and the residuum of weathered bedrock (Geraghty & Miller 1989). The depth to unweathered bedrock varies from less than 10 ft (3 m) to more than 50 ft (15 m), depending on the characteristics of the underlying rocks. Bedrock aquifers in the area are composed of sandstones, siltstones, shales, dolostones, and limestones. The uppermost bedrock aquifer occurs in the Chickamauga Group. Shale beds restrict groundwater flow in the aquifer, resulting in concentrated flow along the limestone-shale contact, with resultant solution cavities. The next lower aquifer occurs in the Knox Group, which is composed of dolostone with interbeds of limestone. Solution features such as sinkholes and caverns are common and are an important route for groundwater flow. This unit is the principal aquifer on the K-25 site (Rothschild et al. 1984).

In 1994 and 1995, groundwater samples were collected from a network of between 200 and 225 monitoring wells at the K-25 site (LMES 1995a, 1996b). The number of wells monitored was greatly decreased in 1996, based on reorganization of the site into six watersheds and reduced monitoring requirements (LMES 1997b). In the 1994 and 1995 sampling conducted for the larger network of monitoring wells, the following substances were detected at levels exceeding their associated primary drinking water standards: antimony, arsenic, barium, cadmium, chromium (up to 0.741 mg/L), fluoride (only at 2 wells), lead, nickel (up to 0.626 mg/L), thallium (up to 0.021 mg/L), benzene (up to 6 :g/L), carbon tetrachloride, 1,1-dichloroethene (greater than 1,000 :g/L), chloroform, 1,2 dichloroethene (greater than 1,000 :g/L), methylene chloride, toluene (greater than 1,000 :g/L), 1,1,2-trichloro-1,2,2-trifluoroethane (greater than 1,000 :g/L), trichloroethylene (up to 11,000 :g/L), 1,1,1-trichloroethane (up to 140,000 :g/L), 1,1,2-trichlororethane, tetrachloroethene (up to 17 :g/L), vinyl chloride, gross alpha activity (up to 43 pCi/L), and gross beta activity (up to 6,770 pCi/L) (LMES 1995a, 1996b). Aluminum, iron, and manganese also consistently exceeded secondary, non-health-based standards because of the natural geochemical nature of the groundwater underlying the site (LMES 1996b).

Exit-pathway groundwater surveillance monitoring was also conducted in 1994 and 1995 at convergence points where shallow groundwater flows from relatively large areas of the K-25 site and converges before discharging to surface water locations (LMES 1995a, 1996b). The exit pathway monitoring data are representative of maximum groundwater contamination levels associated with the K-25 site to which the general public might possibly have access in the future. For 1994, monitoring indicated that thallium, bis(2-ethylhexyl)phthalate, and trichloroethylene were present in at least one exit pathway well sample at concentrations exceeding primary drinking water standards (LMES 1996a). The following average concentrations of these constituents were measured: thallium, 0.007 mg/L; bis(2-ethylhexyl)phthalate, 0.169 mg/L; and trichloroethylene, 0.008 mg/L. Alpha activity and fluoride levels were also measured but did not exceed reference levels (average concentration was 4.4 pCi/L for alpha activity and 0.4 mg/L for fluoride). For 1995, monitoring indicated that no inorganic or organic substances exceeded primary drinking water standards, but alpha activity exceeded the reference level in one well during the spring sampling event only (level of 17 pCi/L) (LMES 1996b).

2.6 BIOTIC RESOURCES

2.6.1 Vegetation

About 65% of the land within a 5-mile (8-km) radius of the K-25 site is forested, although most of the K-25 site consists of mowed grasses. Oak-hickory forest is the predominant community on ridges and dry slopes. Mixed pine forests or pine plantations, many of which are managed, have replaced former agricultural fields. Selective logging occurred over much of the site prior to 1986. Cedar barrens are small communities, primarily on shallow limestone soils, which support drought-tolerant species such as little bluestem, dropseed, eastern red cedar, and stunted oak. A cedar barrens across the Clinch River from the K-25 site may be the best example of this habitat in the state and has been designated a State Natural Area.

2.6.2 Wildlife

The high diversity of habitats in the area supports a large number of wildlife species. Ground-nesting species commonly occurring on the K-25 site include the red fox, ruffed grouse, and eastern box turtle. Canada geese are also common in the K-25 area, and most are probably residents (ANL 1991). Waterfowl, wading birds, and shorebirds are numerous along the Clinch River in its backwaters and in ponds. Two great blue heron rookeries are located north of the K-25 site on Poplar Creek (ANL 1991). Species commonly associated with streams and ponds include the muskrat, beaver, and several species of turtles and frogs.

The aquatic communities within the Clinch River and Poplar Creek support a high diversity of fish species and other aquatic fauna. Mitchell Branch supports fewer fish species, although the diversity of fish species increased considerably downstream of most K-25 discharges between 1989 and 1995 (LMES 1995a).

2.6.3 Wetlands

Numerous wetlands occur in the vicinity of K-25, including three small wetlands along Mitchell Branch (ANL 1991). Extensive forested wetlands occur along Poplar Creek, East Fork Poplar Creek, Bear Creek, and their tributaries. Shallow water embayments of Melton Hill Reservoir and Watts Bar Reservoir support large areas of palustrine emergent wetlands with persistent vegetation. Forested wetlands occur along these marshy areas and extend into tributaries (DOE 1995a).

2.6.4 Threatened and Endangered Species

No federal listed threatened or endangered species are known to occur on the K-25 site. Bachman's sparrow, state-listed as endangered, nests on ORR. Suitable habitat on the reservation includes open pine woods with shrubs and dense ground cover (ANL 1991). Sharp-shinned hawk and Cooper's hawk, both listed by the state as endangered, forage on ORR. The purple fringeless orchid, state-listed as threatened, occurs in a wetland near the south boundary of the K-25 site and in several areas along Bear Creek and its tributaries southeast of K-25.

2.7 PUBLIC AND OCCUPATIONAL HEALTH AND SAFETY

2.7.1 Radiation Environment

Radiation doses to the K-25 cylinder yard workers and to off-site members of the general public are summarized in Table 2.3. Airborne emissions from operations of the K-25 site constitute a small fraction of the emissions from the entire ORR and result in approximately 10 times less exposure of the off-site general public than do emissions from the entire reservation. The total radiation dose to the off-site maximally exposed individual (MEI) of the general public is estimated to be about 4.5 mrem/yr (LMES 1997b). This dose is much less than the maximum dose limit of 100 mrem/yr set for the general public (DOE Order 5400.5) and a small fraction of the dose from natural background and medical sources of radiation.

Between 1991 and 1995, the average annual dose to cylinder yard workers ranged from 32 to 92 mrem/yr, which is less than 2% of the maximum radiation dose limit of 5,000 mrem/yr set for radiation workers (10 CFR Part 835).

2.7.2 Chemical Environment

The estimated hazard quotients for members of the general public under existing environmental conditions near the K-25 site are listed in Table 2.4. The hazard quotient represents a comparison of estimated human intake levels with intake levels below which adverse effects are very unlikely to occur. The estimated hazard quotients indicate that exposures to uranium compounds, fluoride compounds, and other contaminants near the K-25 site are generally lower than those that

TABLE 2.3 Estimated Radiation Doses to Members of the General Public and to Cylinder Yard Workers at the K-25 Site

Receptor	Radiation Source	Dose to Individual (mrem/yr)
Member of the general public (MEI)[a]	Routine site operations	
	Airborne radionuclides[b]	
	K-25 site only	0.056
	Entire ORR	0.45
	Waterborne radionuclides[c]	1.52
	Direct gamma radiation	1[d]
	Ingestion of wildlife	1.58[e]
Cylinder yard worker	External radiation	32 – 92[f]
Member of public or worker	Natural background radiation and medical sources	360[g]
DOE worker limit		2,000[h]

[a] The MEI was assumed to reside at an off-site location that would yield the largest dose. An average person would receive a radiation dose much less than the values shown in this table.

[b] Radiation doses from airborne releases were estimated using an air dispersion model and considered exposures from external radiation, inhalation, and ingestion of foodstuffs. Doses were estimated on the basis of the emission rate from the K-25 site only and from the entire ORR (LMES 1997b).

[c] Radiation doses would result from drinking 730 L of water per year provided by the Kingston Municipal Water Plant (0.32 mrem/yr) and ingesting 21 kg of the maximally contaminated fish caught from lower Poplar Creek per year (1.2 mrem/yr) (LMES 1997b).

[d] Radiation doses would result from 250 hours of shoreline activity per year along the banks of Poplar Creek or Clinch River (LMES 1997b).

[e] Radiation doses would result from ingestion of two deer containing the field-derived concentration of cesium-137 (1.5 mrem/yr) and ingestion of eight Canada geese per year with an average cesium-137 concentration of 0.12 pCi/g (0.08 mrem/yr) (LMES 1997b).

[f] Range of annual average doses from years 1991 through 1995 (Hodges 1996).

[g] Average dose to a member of the U.S. population as estimated in Report No. 93 of the National Council on Radiation Protection and Measurements (NCRP 1987).

[h] DOE administrative procedures limit DOE workers to 2,000 mrem/yr (DOE 1992), whereas the regulatory dose limit for radiation workers is 5,000 mrem/yr (10 CFR Part 835).

TABLE 2.4 Estimated Hazard Quotients for Members of the General Public near the K-25 Site under Existing Environmental Conditions[a]

Environmental Medium	Parameter	Assumed Exposure Concentration	Estimated Chronic Intake (mg/kg-d)	Reference Level[b] (mg/kg-d)	Hazard Quotient[c]
Air[d,e]	Uranium	0.0004 : g/m^3	1.1×10^{-7}	0.0003	0.0004
Soil[d]	Uranium	6.7 : g/g	8.9×10^{-5}	0.003	0.03
	Cadmium	0.34 : g/g	4.5×10^{-6}	0.001	0.0045
	Mercury	0.15 : g/g	2.0×10^{-6}	0.0003	0.0067
	Nickel	33 : g/g	4.4×10^{-4}	0.02	0.022
	Aroclor 1254	0.16 : g/g	2.1×10^{-6}	0.00002	0.11
	Aroclor 1254[f]	0.16 : g/g	9.1×10^{-7}	2.0 (slope factor)	1.8×10^{-6} (cancer risk)
Surface water[d]	Uranium	13 : g/L	7.1×10^{-6}	0.003	0.0024
	Fluoride	180 : g/L	9.9×10^{-5}	0.06	0.0016
Sediments[d]	Uranium	43 : g/g	1.2×10^{-5}	0.003	0.0039
	Cadmium	0.38 : g/g	1.0×10^{-7}	0.001	0.0001
	Mercury	6 : g/g	1.6×10^{-6}	0.0003	0.0055
	Nickel	89 : g/g	2.4×10^{-5}	0.02	0.0012
	Aroclor 1254	10 : g/g	2.7×10^{-6}	0.00002	0.14
	Aroclor 1254[f]	10 : g/g	3.9×10^{-7}	2.0 (slope factor)	7.8×10^{-7} (cancer risk)
Groundwater[g]	Uranium	25 : g/L	1.8×10^{-4}	0.003	0.24
	Fluoride	4,000 : g/L	1.1×10^{-2}	0.06	1.9

[a] The receptor was assumed to be a long-term resident near the site boundary or other off-site monitoring location that would have the highest concentration of the contaminant being addressed; reasonable maximum exposure conditions were assumed. Only the exposure pathway contributing the most to intake levels was considered (i.e., inhalation for air and ingestion for soil, sediment, surface water, and groundwater). Residential exposure scenarios were assumed for air, soil, and groundwater analyses; recreational exposure scenarios were assumed for surface water and sediment analyses.

[b] The reference level is an estimate of the daily human exposure level that is likely to be without an appreciable risk of deleterious effects. The reference levels used in this assessment are defined in Appendix C of the PEIS. For carcinogens, the slope factor is also given; slope factors in units of $(\text{mg/kg-d})^{-1}$ are multiplied by lifetime average intake to estimate excess cancer risk.

[c] The hazard quotient is the ratio of the intake of the human receptor to the reference does. A hazard quotient of less than 1 indicates that adverse health effects resulting from exposure to that chemical alone are highly unlikely. For carcinogens, the cancer risk (intake × slope factor) is also given. Increased cancer risks between 10^{-6} and 10^{-4} are considered tolerable at hazardous waste sites; risks less than 10^{-6} are considered negligible.

[d] Exposure concentrations are the maximum annual averages for all monitoring locations (LMES 1995a, 1996a).

[e] HF was not measured.

[f] Parameters analyzed for carcinogenic effects; all other parameters were analyzed for noncarcinogenic effects.

[g] Concentration for uranium is the maximum annual average for all exit pathway monitoring locations because these are the locations where the general public could most likely be exposed in the future. Alpha activity was used as a surrogate measure of uranium concentration. The well-specific concentration for fluoride was not available; the exposure concentration given is actually the drinking water standard. The hazard index for fluoride could therefore exceed that presented. Several additional substances exceeded drinking water standards or guidelines in 1994 and 1995 monitoring; listed here are only substances of particular interest for the PEIS. Data are from LMES (1996a,b).

might be associated with deleterious health effects (hazard quotient less than 1). An exception is groundwater, where hazard quotients for several substances could exceed the threshold of 1. However, it is highly unlikely that this groundwater will be used as a drinking water source.

Oak Ridge worker exposures are kept below the proposed Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) for uranium compounds (0.05 mg/m^3 for soluble compounds) and hydrogen fluoride (HF) (2.5 mg/m^3) in the workplace (29 CFR Part 1910, Subpart Z, as of March 1998).

2.8 SOCIOECONOMICS

The socioeconomic environment of the Oak Ridge K-25 site was assessed in terms of regional economic activity, population and housing, and local public finances. The region of influence (ROI) consists of Anderson, Knox, Loudon, and Roane Counties in Tennessee; 91.3% of employees at the site currently reside in these counties, with 36% residing in Knox County and 33.3% in Anderson County (DOE 1997a). Allison and Folga (1997) provide a list of the cities and school districts in each county within the ROI, together with supporting data for the socioeconomic characteristics described in this section.

2.8.1 Regional Economic Activity

Employment in the ROI rose relatively steadily between 1980 and 1995, growing from 242,600 to 311,700, an increase of 28.5%. Within the ROI, the largest percent employment increase occurred in Knox County (31.9%), which had 74.6% of total ROI employment in 1995. The U.S. Bureau of Economic Analysis (BEA) projects a 9.4% increase in employment in the ROI over the period 1995 to 2020 (29,400 jobs), with the largest increase expected to occur in Knox County (10.2%, 23,700 jobs) (BEA 1996). Unemployment in the ROI in 1996 was 3.7% (Allison 1996). Employment at the site in 1995 was 21,500 (DOE 1996b), amounting to approximately 4.3% of total employment in the ROI.

Personal income in the ROI rose relatively steadily between 1980 and 1995, growing from \$4.7 billion to \$6.7 billion, an increase of 43%. The largest percent increase occurred in Knox County (48.7%), which had 72.3% of total ROI personal income in 1995. The BEA projects a 40.7% increase in ROI personal income from 1995 to 2020 (\$2.7 billion), with the largest increase in Knox County (41.8%, \$2.0 billion) (BEA 1996).

2.8.2 Population

The ROI experienced small increases in population over the period 1980 to 1995, with total population growing from 464,000 to 506,600, an increase of 9.2%. The 1995 ROI population was concentrated in Knox County (69.8%). The BEA projects the ROI population as a whole to increase by 77,200 (15.2%) from 1995 to 2020, with the largest increase in Knox County (15.9%, 56,300 people) (BEA 1996).

2.8.3 Housing

Between 1980 and 1995, the number of housing units in the ROI increased 13.8%, from 181,300 to 206,200. Knox County had 69.6% of the total housing units. Based on BEA (1996) population forecasts for 1995 to 2020 and U.S. Bureau of the Census (1994) statistics, the number of vacant owner-occupied units in the ROI is expected to increase from 10,190 to 11,750 and the number of vacant rental units from 5,030 to 5,800.

2.8.4 Public Finance

The financial characteristics of local public jurisdictions included in the ROI are summarized in Table 2.5. Data are shown for the major revenue and expenditure categories and for the annual fiscal balance of the general fund account for cities, counties, and school districts.

2.9 WASTE MANAGEMENT

The K-25 site generates industrial and sanitary waste, including wastewater, solid non-hazardous waste, solid and liquid hazardous waste, and radioactive waste. Much of the waste generated at K-25 is by-products of the ongoing environmental remediation efforts at the site. The K-25 site has the capability to treat wastewater and certain radioactive and hazardous waste; other waste treatment facilities that can process and/or dispose of K-25 waste are located at the Y-12 Plant and Oak Ridge National Laboratory. The K-25 waste facilities also store and process waste generated at K-25, as well as waste from Y-12 and Oak Ridge National Laboratory and from other DOE installations at Paducah, Portsmouth, and Fernald. Most radioactive waste at K-25 is contaminated with uranium and uranium decay products, with small amounts of fission products.

The K-25 site is active in the program for waste minimization and recycling at ORR. In 1994, ORR recycled about 700 tons (640 metric tons) of paper, 350 tons (320 metric tons) of cardboard, and 30 to 50 tons (27 to 45 metric tons) of aluminum (LMES 1995a).

TABLE 2.5 Summary of Financial Characteristics for the K-25 Site County, City, and School District Regions of Influence

Category	ROI Counties (Finances[a], $ million)	ROI Cities (Finances[a], $ million)	Category	ROI School Districts (Finances[a], $ million)
Revenues			**Revenues**	
Local sources	66.7	118.6	Local sources	143.6
Fines, fees, permits, etc.	9.1	2.7	State sources	145.7
Intergovernmental	8.9	26.5	Federal sources	3.2
Other	5.4	9.5	Other	1.1
Total	90.1	157.2	Total	323.2
Expenditures			**Expenditures**	
General government	31.5	14.1	Administration	30.2
Safety, health, community services	50.7	91.6	Instruction	189.7
Debt service	0.0	2.3	Services	16.3
Other financing sources	1.3	48.6	Physical plant	17.2
Total	83.4	156.6	Other	16.3
			Total	298.7
Revenues less Expenditures	6.7	0.6	**Revenues less Expenditures**	24.5

[a] Data for fiscal year ending June 30, 1995.

Sources: see Allison and Folga (1997).

The K-25 site and nationwide waste loads assumed for the analysis of impacts of projected activities in this report are given in Table 2.6. Details on the waste management impact assessment methods are provided in Appendix C of the PEIS.

2.9.1 Wastewater

Treated wastewater at the K-25 site is discharged under National Pollutant Discharge Elimination System (NPDES) permit TN0002950. In 1994, the discharge was in compliance more than 99% of the time. Sanitary wastewater is processed at the K-1203 sewage treatment plant, which has a capacity of 0.92 million gal/d (3.5 million L/d). In 1994, the average loading to the facility was 0.64 million gal/d (70% of capacity). Currently, there is a project to reline sewer lines to reduce rainfall infiltration (DOE 1996a).

TABLE 2.6 Projected Site and National DOE Waste Treatment Volumes

Waste Category	Waste Treatment Volume[a] (m^3/yr) K-25 (ORR)[b]	Nationwide
Low-level waste[c]	8,100	68,000[d]
Low-level mixed waste[e]	(5,000)	19,000[d]
Hazardous waste[f]	1,000	-
Nonhazardous waste[f]		
Solids	(27,500)	-
Wastewater	-	-
Sanitary waste	880,000	-

[a] A hyphen (–) indicates no data reported.

[b] Waste treatment volumes for the K-25 site are listed where available. Much of the waste generated at K-25 is included in the combined treatment volumes listed under the Oak Ridge Reservation (ORR) treatment, storage, and disposal facilities. These combined volumes (enclosed in parentheses) include waste generated at ORNL, K-25, and Y-12.

[c] Source: DOE (1995b).

[d] Estimated operational waste for 1995 for all DOE sources combined (DOE 1997a).

[e] Source: DOE (1995c).

[f] Source: DOE (1996a).

2.9.2 Solid Nonhazardous, Nonradioactive Waste

ORR, including the K-25 site, generates about 35,000 yd^3/yr (27,000 m^3/yr) of solid nonhazardous waste. The waste is disposed of at the Y-12 landfill, which has a capacity of 405,000 yd^3 (310,000 m^3) (DOE 1996a). An additional 1.8 million yd^3 (1.4 million m^3) of capacity will be developed at the landfill. Given current and/or future projected waste loading, the landfill will have approximately 50% of capacity, or 920,000 yd^3 (700,000 m^3), available in the year 2020.

2.9.3 Nonradioactive Hazardous and Toxic Waste

The K-25 site generates both RCRA-hazardous and TSCA-hazardous waste. The site operates several RCRA Part B hazardous waste treatment/storage facilities. The majority of the hazardous waste consists of PCB-containing solids and liquids regulated according to TSCA guidelines. In 1992, the site generated 1,124 tons (1,020 metric tons) of PCB waste. The site operates a permitted TSCA incinerator to treat hazardous and low-level mixed waste (LLMW; hazardous waste plus low-level radioactive waste) liquids contaminated with PCBs. The incinerator also processes PCB waste from other facilities at ORR and from off-site DOE installations. Total capacity of the TSCA incinerator is 1,800 yd^3/yr (1,400 m^3/yr). The K-25 waste input of 1,300 yd^3/yr (1,000 m^3/yr) (DOE 1996a) represents 70% of incinerator capacity. In 1991, the hazardous waste generation for ORR was 154 yd^3 (118 m^3). On-site storage capacity for hazardous waste is 16,100 yd^3 (12,300 m^3).

2.9.4 Low-Level Waste

The K-25 site generated approximately 1,400 yd^3 (1,100 m^3) of solid low-level radioactive waste (LLW) in 1992 and approximately 10,600 yd^3 (8,100 m^3) in 1993. ORR has a compaction/ shredding facility with the capacity to treat approximately 1,800 yd^3/yr (1,400 m^3/yr) of LLW. ORR disposed of approximately 1,100 yd^3 (840 m^3) of LLW in 1994. LLW that is not treated or disposed of on-site at ORR is placed in storage, pending either treatment or disposal, or both, at off-site facilities. In 1993, approximately 57,900 yd^3 (44,300 m^3) of LLW was in storage at the K-25 site (DOE 1996a).

2.9.5 Low-Level Mixed Waste

The majority of radioactive waste generated at the K-25 site is LLMW. The site LLMW consists of two major categories: (1) aqueous RCRA-hazardous radioactive waste contaminated with corrosives or metals and (2) organic liquids contaminated with PCBs. About 4,000 yd^3 (3,000 m^3) of contaminated soil (LLMW) is stored at ORR.

In 1992, the K-25 site generated 100,000 yd^3 (76,000 m^3) of liquid LLMW. Aqueous LLMW is treated at the K-1407H central neutralization facility, which processes aqueous waste by pH adjustment of corrosives and chemical precipitation of metals. Treated wastewaters are discharged to the NPDES-permitted discharges, which have a capacity of 450,000 yd^3/yr (340,000 m^3/yr). The K-25 TSCA incinerator, with a capacity of 1,800 yd^3/yr (1,400 m^3/yr), is used to treat organic LLMW liquids contaminated with PCBs. Total K-25 input to the TSCA incinerator (both PCB-contaminated radioactive and nonradioactive waste) is approximately 1,300 yd^3/yr (1,000 m^3/yr).

The K-25 site has the capability to treat approximately 6,500 yd^3/yr (5,000 m^3/yr) of liquid LLMW via grout stabilization. The site currently stores 38,000 yd^3 (29,000 m^3) of grouted LLMW (DOE 1996a), with a capacity for 88,600 yd^3 (67,800 m^3) of LLMW container storage. The current inventory of LLMW stored at ORR (and the K-25 site) is proposed to be treated in ORR facilities. The planned waste treatment will require more than 20 years to complete (LMES 1995b).

2.10 CULTURAL RESOURCES

An archaeological survey was completed at the K-25 site during 1994. This survey confirmed findings of previous surveys of ORR, which had identified 45 prehistoric sites, 10 of which are potentially eligible for the *National Register of Historic Places*. Twelve of the sites are located near the K-25 site (Fielder 1974). More than 240 historic resources have also been recorded at ORR; six are listed on the *National Register*, and 20 or more may be eligible.

The K-25 site was associated with the Manhattan Project and played a significant role in the production of highly enriched uranium for weapons manufacture between 1944 and 1964. Buildings at the K-25 site were evaluated in 1994. One historic district, the Main Plant Historic District, is eligible for the *National Register*. The district consists of 157 buildings, of which 120 buildings contribute to the district and 37 do not. Eleven additional buildings not adjacent to the district are also considered eligible based on their supporting roles in the uranium-235 enrichment process. The George Jones Memorial Baptist Church and Cemetery (established 1901) is also located on the K-25 site and is included in the *National Register*.

On May 6, 1994, a programmatic agreement concerning management of historic properties on ORR was signed by the DOE Oak Ridge Operations Office, the Advisory Council on Historic Preservation, and the Tennessee State Historic Preservation Officer. This agreement concerned management of significant cultural resources that meet eligibility criteria for listing in the *National Register*. DOE committed to developing a draft cultural resources management plan within 2 years of the signing of the agreement. The draft plan was completed in May 1996 and is currently being reviewed. Once final, this plan will supersede the programmatic agreement.

The Overhill Cherokee occupied part of eastern Tennessee from the 1700s until their relocation to Oklahoma in 1838. However, no religious or sacred sites, burial sites, or resources significant to the Overhill Cherokee have been identified at the K-25 site to date.

2.11 MINORITY AND LOW-INCOME POPULATIONS

Demographic information obtained from the U.S. Bureau of the Census was used to profile the population residing within a 50-mile (80-km) radius of the Paducah site. A 50-mile (80-km) radius was selected because it would capture virtually all of the human health risks and environmental impacts that could potentially occur. A geographic information system based on 1990 Census Bureau *Tiger Line Files* and Summary Tape Files 1 and 3A was utilized to generate a map illustrating minority and low-income populations residing within the 50-mile (80-km) zone of impact surrounding the site (U.S. Bureau of the Census 1992a,b,c).

The unit of analysis was the census tract. For those census tracts only partially located inside a 50-mile (80-km) radius of the site, an even population distribution was assumed, and the population was calculated as a proportion of the tract area physically located within the 50-mile (80-km) radius (i.e., if 50% of the census area was inside of the 50-mile (80-km) radius, then 50% of its population was counted). The map is presented as Figure 2.5 and depicts the distribution of minority and low-income census tracts within a 50-mile (80-km) radius of the K-25 site. Information regarding the proportion of the total population residing within 50 miles (80 km) of the site that is minority or low-income accompanies the figure.

The proportion thresholds for determining the low-income and/or minority status of a census tract were based on the proportion of low-income and minority populations residing within the state of Kentucky. If the 50-mile (80-km) radius around the site included a portion of another state or states, a weighted average based on all the affected state low-income and minority population proportions was assigned. Other reference threshold proportions were considered (i.e., national, multistate regional), but state population proportions were chosen because they tend to present a more accurate portrayal of the affected populations. The population residing within a 50-mile (80-km) radius of the K-25 site consists of 6.1% minorities and 16.2% persons with low income.

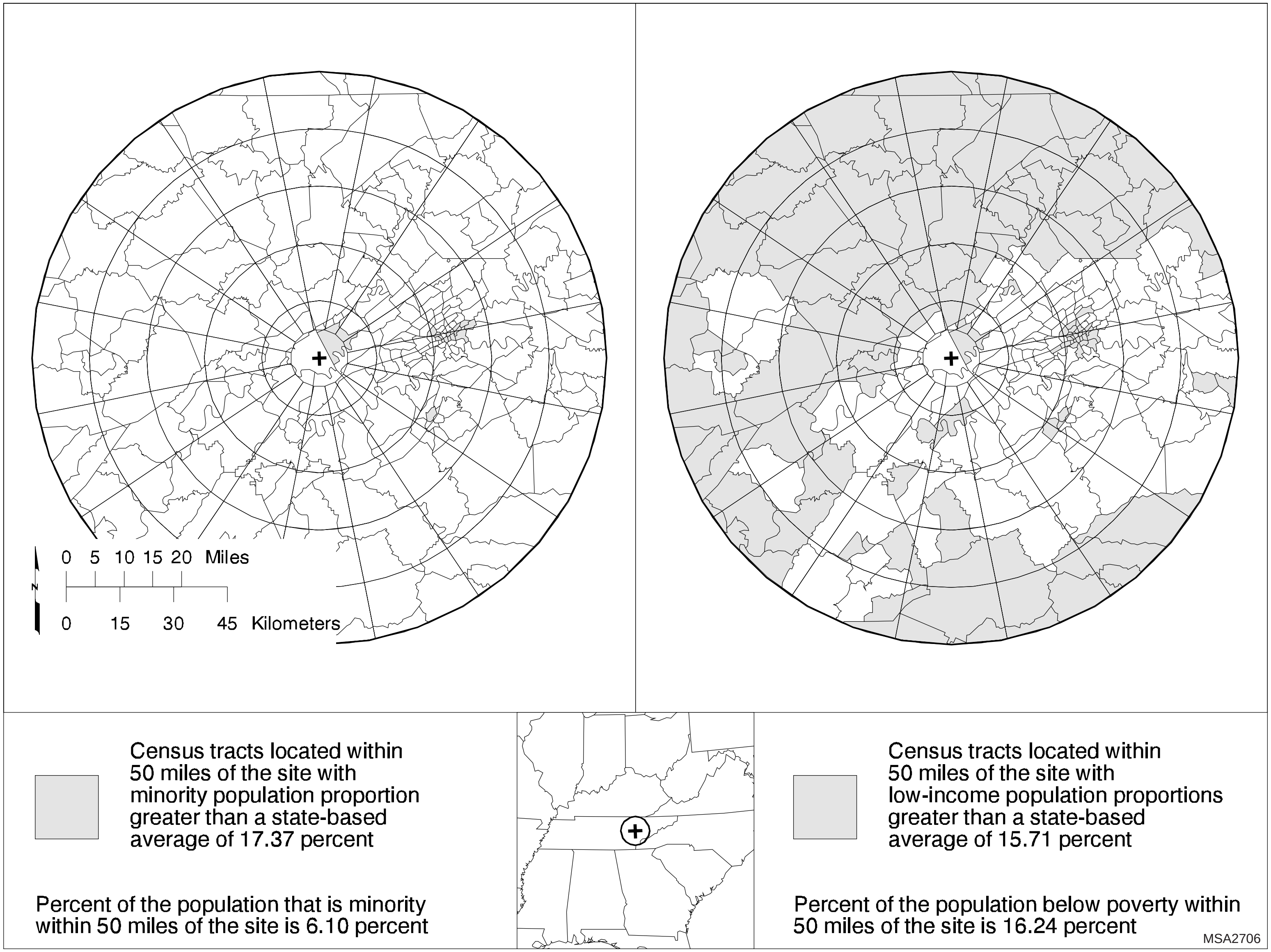

FIGURE 2.5 Distribution of Minority and Low-Income Census Tracts within a 50-Mile Radius of the K-25 Site

3 ENVIRONMENTAL IMPACTS OF CONTINUED CYLINDER STORAGE AT THE K-25 SITE

Continued cylinder storage at the K-25 site would be required for some period of time for all alternative management strategies. It was assumed that the entire depleted UF_6 cylinder inventory would continue to be stored at the K-25 site through 2008 for all alternatives. Under the no action alternative, the entire cylinder inventory would continue to be stored at the site indefinitely. For purposes of analysis and for comparison with action alternatives, the assessment period considered was through the year 2039. Under action alternatives, the number of cylinders stored at the site was assumed to decrease as the cylinders were transported to another location for conversion or long-term storage. This decrease was assumed to occur from 2009 through 2028.[1] The assessment of impacts from continued cylinder storage considers all anticipated activities required to safely manage the cylinder inventory from 1999 through 2039 for the no action alternative and from 1999 through 2028 for the action alternatives. Potential long-term impacts from cylinder breaches potentially occurring at the site through the year 2039 (no action alternative) or through 2028 (action alternatives) were estimated by calculating the maximum groundwater contamination levels possible in the future from those breaches.

Continued Storage of Cylinders

The continued storage of depleted UF_6 cylinders at the K-25 site would be required for some period of time for all alternative management strategies. Continued storage would involve maintenance of the cylinders — including inspections, painting, and cylinder yard upgrades — as well as valve replacement and cylinder repair, as needed. The impacts of continued storage at the K-25 site were assessed separately for the following:

No Action Alternative: Potential impacts were assessed for continued storage of the entire cylinder inventory at the K-25 site through the year 2039, including potential long-term impacts to groundwater and human health and safety.

Action Alternatives: Potential impacts were assessed for continued storage at the K-25 site based on the assumption that the number of cylinders at the site would begin to decrease in the year 2009 and that all of the cylinders would be removed by the end of the year 2028 (corresponding to the period during which conversion or long-term storage would be implemented). Potential long-term impacts were also assessed.

The cylinder surveillance and maintenance activities that are to be undertaken from now through September 30, 2002, are described in detail in the *UF_6 Cylinder Project Management Plan* (LMES 1997d). However, because the assessment period extends through the year 2039, a set of assumptions was needed to define the activities for estimating the impacts of

[1] These estimates were meant to provide a consistent analytical time frame for the evaluation of all the PEIS alternatives and do not represent a definitive schedule.

continued storage through 2039. The assumptions used are documented in a memo by J.W. Parks, Assistant Manager for Enrichment Facilities, DOE Oak Ridge Operations Office (Parks 1997). In developing these assumptions, it was recognized that the activities actually undertaken might differ from those described in the cylinder project management plan. Therefore, assumptions were chosen such that anticipated impacts of continued cylinder storage made in the PEIS would result in conservative estimates (that is, the assumptions used would overestimate impacts rather than underestimate them).

Impacts associated with the following activities were analyzed: (1) storage yard reconstruction and cylinder relocations, (2) routine and ultrasonic testing inspections of cylinders and valve monitoring and maintenance, (3) cylinder painting, and (4) repair and removal of the contents of any cylinders that might be breached during the storage period. Although actual activities occurring during the time period considered might vary from those described in the cylinder project management plan, the estimated impacts of continued storage activities assessed in the PEIS are likely to encompass and bound the impacts. The assumptions for each activity are discussed further in the following paragraphs.

The inventory of depleted UF_6 cylinders generated by DOE before 1993 that is stored in three yards at the K-25 site is 4,683 cylinders (about 10% of the total inventory). An intensive effort is ongoing to improve yard storage conditions. This effort includes (1) relocation of some cylinders, which are currently either in contact with the ground or are too close to one another to allow for adequate inspections, and (2) construction of new storage yards or reconstruction of existing storage yards to provide a stabilized concrete base and monitored drainage for the cylinder storage areas. The impacts from planned relocation and construction activities that will not be complete by 1999 are included in the PEIS for consideration as part of continued cylinder storage; these activities include construction of a new yard for the K-25 site cylinders and relocation of all cylinders at K-25.

The stored cylinders are regularly inspected for evidence of damage or accelerated corrosion; about 75% are inspected every 4 years, and 25% are inspected annually. Annual inspections are required for those cylinders that have been stored previously in substandard conditions and/or those that show areas of heavy pitting or corrosion. In addition to these routine inspections, ultrasonic inspections are currently conducted on some of the relocated cylinders. The ultrasonic testing is a nondestructive method to measure the wall thickness of cylinders. Valve monitoring and maintenance are also conducted for cylinders that exhibit discoloration of the valve or surrounding area during routine inspections. Leaking valves are replaced in the field. Impacts from routine inspections, ultrasonic inspections, and valve maintenance are evaluated as components of continued cylinder storage. For assessment of the no action alternative, the frequency of routine inspections and valve monitoring was assumed to remain constant through 2039, and ultrasonic testing was assumed to be conducted annually for 10% of the relocated cylinders. Relocation activities would be completed in about 2003, after which 10% of the cylinders painted each year were assumed to be inspected by ultrasonic testing. For the action alternatives, the frequency of inspections was assumed to decrease with decreasing cylinder inventory (about a 5% decrease in inspections per year) from 2009 through 2028.

Current plans call for cylinder painting to control cylinder corrosion. On the basis of information from the cylinder painting program (Pawel 1997), the analysis assumed that the paint would protect the cylinders for at least 10 years and that, once painted, the cylinders would not undergo further corrosion during that time. Although repainting might not actually be required every 10 years, the analysis assumed that every cylinder would be repainted every 10 years (except for the period 2019 through 2028 for the action alternatives, during which time no painting was assumed because of decreasing inventory size — i.e., cylinders being removed within 10 years for conversion or long-term storage elsewhere would not be repainted). The painting activity includes cylinder surface preparation (e.g., scraping and removal of rust deposits). Because some radioactive contaminants may exist on the surface of cylinders and because the metal content of the paints used previously are unknown, for purposes of analysis the waste generated during surface preparation was considered to be low-level-mixed waste. Cylinder painting activities would be the primary source of potential radiological exposures for involved workers under the continued cylinder storage option.

Before 1998, four breached cylinders had been identified at the K-25 site. A breached cylinder is a cylinder that has a hole of any size at some location on the wall. Investigation of the breaches indicated that two of the four were initiated by mechanical damage during stacking; the damage was not noticed immediately, and subsequent corrosion occurred at the damaged points. The other two cylinder breaches were concluded to have been caused by external corrosion due to prolonged ground contact. The hole sizes in the four breached cylinders were 2 in. (5.1 cm) in diameter (cylinder stored for about 16 years), 6 in. (15 cm) in diameter (cylinder stored for about 28 years), 10 in. (25 cm) in diameter (cylinder stored for about 33 years), and 17 × 12 in. (43 × 30 cm) (cylinder stored for about 17 years). Because equipment to weigh the cylinders was not available at the K-25 site, the extent of material loss from the cylinders could not be determined. When cylinders are breached, moist air reacts with the exposed UF_6 and iron, resulting in the formation of a dense plug of uranium tetrafluoride (UF_4) and iron fluoride hydrates that prevents rapid loss of material from the cylinders, although slow corrosion continues. Further details on cylinder corrosion and releases due to breaches are given in Appendix B of the PEIS.

In 1998, one additional breached cylinder occurred during the course of cylinder maintenance operations. Previous corrosion modeling had predicted that some additional cylinder breaches would be detected during such activities (see Table 3.1). The breach occurred during steel grit blasting of the cylinder surface in preparation for painting. An as-fabricated weld defect was opened by the blast process. The cylinder management program includes provisions for patching newly identified breached cylinders to eliminate releases of material.

Considering the improved storage conditions in the yards, intensive inspection schedule, and the planned cylinder painting, the impact analysis for the no action alternative was based on the

TABLE 3.1 Estimated Number of Breaches and Releases from 4,683 DOE-Generated Cylinders at the K-25 Site from 1999 through 2039, Assuming Control of External Corrosion by Painting[a]

Year of Breach	Number of Breaches[b]	Number of Active Breaches[c]	HF Emissions[d] (kg/yr)	Year of Breach	Number of Breaches[b]	Number of Active Breaches[c]	HF Emissions[d] (kg/yr)
1999	1	1	2	2020	1	1	2
2000	1	2	4	2021	0	1	2
2001	0	2	4	2022	0	1	2
2002	0	2	4	2023	0	1	2
2003	0	1	2	2024	0	0	0
2004	0	0	0	2025	0	0	0
2005	0	0	0	2026	0	0	0
2006	0	0	0	2027	0	0	0
2007	0	0	0	2028	0	0	0
2008	1	1	2	2029	1	1	2
2009	0	1	2	2030	0	1	2
2010	0	1	2	2031	0	1	2
2011	1	2	4	2032	0	1	2
2012	0	1	2	2033	0	0	0
2013	0	1	2	2034	0	0	0
2014	0	1	2	2035	0	0	0
2015	0	0	0	2036	0	0	0
2016	0	0	0	2037	0	0	0
2017	0	0	0	2038	1	1	2
2018	0	0	0	2039	0	1	2
2019	0	0	0	Total	7		

[a] PEIS analyses conducted for the period 1999 through 2039. Existing models also predicted one possible breach due to corrosion for 1998.

[b] Estimates based on the assumption that a painting program would be effective in eliminating external corrosion by the year 2009. Breaches prior to 2009 were calculated as the sum of corrosion-initiated breaches for the proportion left unpainted in each year (based on external corrosion statistical model [Lyon 1996, 1997]) plus the handling-initiated breaches. For 2009–2039, only handling-initiated breaches were assumed. The breaches were assumed to go undetected for 4 years; in practice, improved storage conditions and maintenance and inspection procedures should prevent any breaches from occurring or going undetected for long periods.

[c] Number of active breaches = sum of current-year breaches and previous-3-year breaches, based on 4-year inspection intervals. Annual uranium emissions (lb/yr) = number of active breaches in that year (1 lb per active breach per year).

[d] Annual HF emissions (kg/yr) = number of active breaches × 0.0055 kg per breached cylinder per day × 365 days per year.

assumption that breaches resulting from corrosion would cease. Therefore, the primary potential cause of breaches considered for continued storage was mechanical damage occurring during cylinder handling (e.g., for painting or relocations). Although stringent inspection procedures are now in place to immediately identify and repair any cylinder breaches that might occur during handling, for purposes of analysis it was nonetheless assumed that breaches caused by mechanical damage would continue to occur at the same rate as in the past and that the breaches would go unidentified for a long enough time for releases to occur (see Appendix B of the PEIS). On the basis of these assumptions, the total numbers of breaches assumed to occur from 1999 through 2039 for the no action alternative analyses (base case) was 7 for the K-25 site (Table 3.1).

The above breach number was used to estimate potential impacts from repairing breached cylinders and from releases that might occur during continued storage through 2039 under the no action alternative. Potential radiological exposures of involved workers could result from patching breached cylinders and subsequently emptying the cylinder contents into new cylinders. The impacts to groundwater and human health and safety from uranium releases were assessed by estimating the amount of uranium that could be transported from the yards in surface runoff, followed by estimating migration through the soil to the groundwater.

The uncertainty in both the effectiveness of painting in controlling further corrosion and in the future painting schedule was addressed by also conducting a conservative assessment based on the assumption that external corrosion would not be halted by improved storage conditions and painting, resulting in more breaches (see Section 3.3). Using these assumptions, the total number of breaches estimated from 1999 through 2039 was 213 for the K-25 site (Table 3.2). The results of this assessment were used to provide an estimate of the earliest time when continued cylinder storage could begin to raise regulatory concerns under these worst-case conditions.

For the action alternatives, continued storage would occur through 2028, with the inventory decreasing by about 5% per year starting in 2009 until no cylinders would remain at the current sites in 2028. Because the status of a cylinder painting program is less certain for the action alternatives, the estimated number of breached cylinders for these alternatives was based on the assumption that external corrosion was not controlled by painting (see Section 3.4 for a discussion of the potential impacts for the action alternatives).

For all hypothetical cylinder breaches, it was assumed that the breach would go undetected for a period of 4 years, which is the duration between planned inspections for most of the cylinders. In practice, cylinders that show evidence of damage or heavy external corrosion are inspected annually, so it is unlikely that a breach would go undetected for a 4-year period. On the basis of estimates from investigation of cylinder breaches that have occurred to date, 1 lb (0.45 kg) of uranium (in the form of uranyl fluoride [UO_2F_2]) and 4.4 lb (2 kg) of HF were assumed to be released from each breached cylinder annually for a period of 4 years (see Tables 3.1 and 3.2).

TABLE 3.2 Estimated Number of Breaches and Releases from DOE-Generated Cylinders at the K-25 Site from 1999 through 2039, Assuming Historical Corrosion Rates

	Breaches and Releases at K-Yard (2,945 Cylinders)			Breaches and Releases at E-Yard and L-Yard (1,738 Cylinders)		
Year of Breach	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)
1999	1	1	2	0	0	0
2000	0	1	2	0	0	0
2001	0	1	2	0	0	0
2002	0	1	2	0	0	0
2003	0	0	0	0	0	0
2004	0	0	0	0	0	0
2005	2	2	4	1	1	2
2006	1	3	6	1	2	4
2007	0	3	6	0	2	4
2008	2	5	10	0	2	4
2009	0	3	6	0	1	2
2010	1	3	6	0	0	0
2011	2	5	10	0	0	0
2012	2	5	10	0	0	0
2013	2	7	14	0	0	0
2014	2	8	16	1	1	2
2015	2	8	16	0	1	2
2016	2	8	16	1	2	4
2017	2	8	16	0	2	4
2018	3	9	18	0	1	2
2019	3	10	20	1	2	4
2020	4	12	24	1	2	4
2021	4	14	28	1	3	6
2022	4	15	30	1	4	8
2023	5	17	34	0	3	6
2024	6	19	38	1	3	6
2025	6	21	42	0	2	4
2026	7	24	48	0	1	2
2027	6	25	50	1	2	4
2028	7	26	52	1	2	4
2029	8	28	56	0	2	4
2030	9	30	60	1	3	6
2031	10	34	68	1	3	6
2032	8	35	70	1	3	6
2033	11	38	76	1	4	8
2034	11	40	80	1	4	8

TABLE 3.2 (Cont.)

	Breaches and Releases at K-Yard (2,945 Cylinders)			Breaches and Releases at E-Yard and L-Yard (1,738 Cylinders)		
Year of Breach	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)	Number of Breaches[a]	Number of Active Breaches[b]	HF Emissions[c] (kg/yr)
2035	11	41	82	1	4	8
2036	12	45	90	1	4	8
2037	12	46	92	1	4	8
2038	12	47	94	1	4	8
2039	12	48	96	1	4	8
Total[d]	192			21		

[a] These estimates are conservative estimates used for assessing potential impacts based on an external corrosion statistical model (Lyon 1996, 1997). The estimates were based on the assumption that historical corrosion rates would continue through 2039 (i.e., that corrosion would not have been eliminated by painting and maintenance). In practice, painting of cylinders, improved storage conditions, and maintenance and inspection procedures should prevent any breaches from occurring or from going undetected for long periods.

[b] Number of active breaches = sum of current-year breaches and previous-3-year breaches, based on 4-year inspection intervals. Annual uranium emissions (lb/yr) = number of active breaches in that year (1 lb per active breach per year).

[c] Annual HF emissions (kg/yr) = number of active breaches × 0.0055 kg per breached cylinder per day × 365 days per year.

[d] Total at site = 213 (192 + 21).

3.1 SUMMARY OF CONTINUED CYLINDER STORAGE IMPACTS

This section provides a summary of the potential environmental impacts associated with continued cylinder storage at the K-25 site for the no action alternative and for the other alternatives. Additional discussion and details related to the assessment methodologies and results for each area of impact are provided in Sections 3.2 and 3.4. The potential environmental impacts of continued cylinder storage are summarized in Table 3.3 and as follows:

- Through the year 2039 for the no action alternative and the year 2028 for the action alternatives, all health and safety impacts to workers and the general public in the vicinity of the sites as a result of cylinder storage and maintenance activities are estimated to be well within the applicable health and safety standards.

TABLE 3.3 Summary of Continued Cylinder Storage Impacts at the K-25 Site[a]

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
Human Health – Normal Operations: Radiological			
Involved Workers: Total collective dose: 200 person-rem	**Involved Workers:** No impacts	**Involved Workers:** Total collective dose: 90 person-rem	**Involved Workers:** No impacts
Total number of LCFs: 0.08 LCF		Total number of LCFs: 0.04 LCF	
Noninvolved Workers: Maximum annual dose to MEI : 0.048 mrem/yr	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** Maximum annual dose to MEI : 0.17 mrem/yr	**Noninvolved Workers:** No impacts
Maximum annual cancer risk to MEI: 2×10^{-8} per year		Maximum annual cancer risk to MEI: 7×10^{-8} per year	
Total collective dose: 0.009 person-rem		Total collective dose (3 sites): 0.093 person-rem	
Total number of LCFs: 4×10^{-6} LCF		Total number of LCFs: 4×10^{-5} LCF	
General Public: Maximum annual dose to MEI: 0.16 mrem/yr	**General Public:** Maximum annual dose to MEI: 0.051 – 0.49 mrem/yr	**General Public:** Maximum annual dose to MEI: 0.46 mrem/yr	**General Public:** Maximum annual dose to MEI: 0.077 – 0.64 mrem/yr
Maximum annual cancer risk to MEI: 8×10^{-8} per year	Maximum annual cancer risk to MEI: $3 \times 10^{-8} – 2 \times 10^{-7}$ per year	Maximum annual cancer risk to MEI: 2×10^{-7} per year	Maximum annual cancer risk to MEI: $4 \times 10^{-8} – 3 \times 10^{-7}$ per year
Total collective dose to population within 50 miles: 0.11 person-rem	Total collective dose to population within 50 miles: not determined	Total collective dose to population within 50 miles: 0.51 person-rem	Total collective dose to population within 50 miles: not determined
Total number of LCFs in population within 50 miles: 6×10^{-5} LCF	Total number of LCFs in population within 50 miles: not determined	Total number of LCFs in population within 50 miles: 0.0003 LCF	Total number of LCFs in population within 50 miles: not determined

TABLE 3.3 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
		Human Health – Normal Operations: Chemical	
Noninvolved Workers: No impacts **General Public:** No impacts	**Noninvolved Workers:** No impacts **General Public:** No impacts	**Noninvolved Workers:** No impacts **General Public:** No impacts	**Noninvolved Workers:** No impacts **General Public:** No impacts
		Human Health – Accidents: Radiological	
Bounding accident: vehicle-induced fire, 3 full 48G cylinders;[b] bounding accident frequency: 1 in 10,000 years to 1 in 1 million years **Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 16 person-rem Number of LCFs: 6×10^{-3} **General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.01 rem Risk of LCF to MEI: 5×10^{-6} Collective dose to population within 50 miles: 63 person-rem Number of LCFs in population within 50 miles: 3×10^{-2}	No accidents	Bounding accident: vehicle-induced fire, 3 full 48G cylinders;[b] bounding accident frequency: 1 in 10,000 years to 1 in 1 million years **Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 16 person-rem Number of LCFs: 6×10^{-3} **General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.01 rem Risk of LCF to MEI: 5×10^{-6} Collective dose to population within 50 miles: 63 person-rem Number of LCFs in population within 50 miles: 3×10^{-2}	No accidents

TABLE 3.3 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
Human Health – Accidents: Chemical			
Bounding accident: vehicle-induced fire, 3 full 48G cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects);[b] Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years (vehicle-induced fire); 1 in 100 to 1 in 10,000 (cylinder spill)	No accidents	Bounding accident: vehicle-induced fire, 3 full 48G cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects);[b] Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years (vehicle-induced fire); 1 in 100 to 1 in 10,000 (cylinder spill)	No accidents
Noninvolved Workers: Bounding accident consequences (per occurrence):		**Noninvolved Workers:** Bounding accident consequences (per occurrence):	
Number of persons with potential for adverse effects: 770 persons		Number of persons with potential for adverse effects: 770 persons	
Number of persons with potential for irreversible adverse effects: 140 persons		Number of persons with potential for irreversible adverse effects: 140 persons	
General Public: Bounding accident consequences (per occurrence):		**General Public:** Bounding accident consequences (per occurrence):	
Number of persons with potential for adverse effects: 550 persons		Number of persons with potential for adverse effects: 550 persons	
Number of persons with potential for irreversible adverse effects: 0 person		Number of persons with potential for irreversible adverse effects: 0 person	

TABLE 3.3 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
Human Health – Accidents: Physical Hazards			
Construction and Operations: **All Workers:** 0.026 fatalities; 33 injuries	No activities in the long term	**Construction and Operations:** **All Workers:** 0.02 fatalities; 23 injuries	No activities in the long term
Air Quality			
Construction: 24-hour PM_{10} potentially as large as 96% of standard; concentrations of other pollutants all below 3% of respective standards **Operations:** 24-hour HF impact potentially as large as 23% of standard. Criteria pollutant impacts all below 0.3% of respective standards.	No activities in the long term	**Construction:** 24-hour PM_{10} potentially as large as 96% of standard; concentrations of other pollutants all below 3% of respective standards **Operations:** 24-hour HF impact potentially as large as 92% of standard. Criteria pollutant impacts all below 0.1% of respective standards.	No activities in the long term
Water			
Construction: Negligible impacts **Operations:** Negligible impacts to surface water and groundwater	Negligible impacts to surface water and groundwater in the long term	**Construction:** No impacts **Operations:** Negligible impacts to surface water; negligible to minor impacts to groundwater	Negligible impacts to surface water and groundwater in the long term
Soil			
Construction: Minor, but temporary, impacts **Operations:** Negligible impacts	No activities in the long term	**Construction:** No impacts **Operations:** Negligible impacts	No activities in the long term

TABLE 3.3 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
		Socioeconomics[c]	
Jobs: 10 in single year of construction, 30 per year over 40 years, operations **Income:** \$0.4 million in single year of construction, \$2.7 million per year over 40 years, operations **Construction and Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public housing	No activities in the long term	**Jobs:** 10 in single year of construction; 40 per year over 30 years, operations **Income:** \$0.4 million in single year of construction, \$3.8 million per year over 30 years, operations **Construction and Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public housing	No activities in the long term
		Ecology	
Construction: Negligible impacts **Operations:** Negligible impacts to vegetation and wildlife	Negligible impacts to vegetation and wildlife in the long term	**Construction:** Negligible impacts **Operations:** Negligible impacts to vegetation and wildlife	Negligible to low impacts to vegetation and wildlife in the long term
		Waste Management	
Negligible impacts for the K-25 site; negligible impacts to regional or national waste management operations	No activities in the long term	Negligible impacts for the K-25 site; negligible impacts to regional or national waste management operations	No activities in the long term
		Resource Requirements	
Negligible impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No activities in the long term	Negligible impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No activities in the long term

TABLE 3.3 (Cont.)

No Action Alternative		Action Alternatives	
Impacts during Storage (1999–2039)	Long-Term Impacts	Impacts during Storage (1999–2028)	Long-Term Impacts
Land Use			
Negligible impacts	No activities in the long term	Negligible impacts	No activities in the long term
Cultural Resources			
Impacts cannot be determined for construction	No activities in the long term	Impacts cannot be determined for construction	No activities in the long term
Environmental Justice			
No disproportionate impacts	No activities in the long term	No disproportionate impacts	No activities in the long term

[a] Under the no action alternative, continued storage of the cylinder inventory would take place at the K-25 site; under the action alternatives, the number of cylinders stored would decrease by 5% annually from 2009 through 2028. Under all alternatives, potential long-term impacts were evaluated for uranium contamination of soil and groundwater from cylinder breaches through 2028 or 2039. HF = hydrogen fluoride; LCF = latent cancer fatality; MEI = maximally exposed individual; PM_{10} = particulate matter with a mean diameter of 10 :m or less; ROI = region of influence.

[b] The bounding radiological accident was defined as the accident that would result in the highest dose and risk to the general public MEI; the bounding chemical accident was defined as the accident that would result in the highest population risk (number of people affected).

[c] Direct jobs and income are presented for the peak year of construction and for the peak year of operations. See Sections 3.2.5 and 3.4.5 for details on indirect impacts in the K-25 site ROI.

- All postulated accidents, including the highest consequence accidents, were estimated to result in zero latent cancer fatalities (LCFs) due to radiological causes among both workers and members of the general public. Some accidents, if they occurred, could result in up to 140 irreversible adverse effects among workers due to chemical effects of released materials. However, such accidents have a very low probability and would not be expected to occur through the year 2039 for the no action alternative and the year 2028 for the action alternatives.

- During the assessment period (through 2039 under the no action alternative and 2028 under the action alternatives), all environmental impacts resulting from continued storage activities, including impacts to air resources, water resources, socioeconomics, ecological resources, waste management, land and other resources, cultural resources, and the environmental justice impacts would be negligibly small or well within the applicable standards.

- Long-term impacts from cylinder breaches estimated to occur through 2039 under the no action alternative would be well within the applicable standards assuming that cylinder painting would be effective in controlling corrosion. If no credit were taken for corrosion reduction through painting and continued maintenance, and on the basis of conservative estimates of numbers of breaches and material loss from breached cylinders, it is estimated that the uranium concentrations in the groundwater around the site would exceed the guideline of 20 : g/L used for comparison at some time in the future (around the year 2100 or later). Similarly, if the larger number of cylinder breaches occurred because of uncontrolled cylinder corrosion, air concentrations of HF at the site could exceed the State of Tennessee standard around the year 2020. For the action alternatives, all long-term impacts are estimated to remain within the guideline values with or without taking credit for reduced corrosion through painting.

3.2 POTENTIAL IMPACTS OF CONTINUED CYLINDER STORAGE FOR THE NO ACTION ALTERNATIVE

The potential environmental impacts from continued cylinder storage for the no action alternative were evaluated on the basis of activities that were assumed to be required to ensure safe storage of the cylinders (Parks 1997). These activities include routine and ultrasonic inspections of cylinders, valve maintenance, cylinder painting, storage yard reconstruction, and cylinder relocations. Although these activities would minimize the occurrence of cylinder breaches and would aid in the early identification of breached cylinders, the impacts associated with cylinder breaches that might occur during continued storage were assessed. The assessment methodologies are described in Appendix C of the PEIS.

Assumptions for continued storage were generally selected in a manner intended to produce conservative estimates of impact, that is, the assumptions result in an overestimate of the expected impact. Therefore, although actual activities occurring at the site during the time period considered might vary, the estimated impacts of continued storage activities assessed are likely to encompass and bound the impacts that could occur. The following general assumptions apply to continued cylinder storage for the no action alternative:

- The current inventory of cylinders at the site would be maintained through the year 2039.

- The number of breaches assumed to occur under the no action alternative accounts for continued external corrosion prior to the completion of painting of the cylinder inventory. After painting, external corrosion was assumed to cease. Estimated numbers of breaches initiated by mechanical damage caused during cylinder handling are also included. Although current maintenance procedures would most likely lead to immediate identification and repair of any cylinder breaches, some releases of uranium and HF from breached cylinders were assumed for assessment purposes. Impacts were assessed for workers handling the breached cylinders, as well as for noninvolved workers and members of the general public exposed to materials released from breached cylinders.

- To assess potential long-term impacts to groundwater and human health and safety from breached cylinders, potential future groundwater contamination was assessed by assuming that released uranium would be transported from the cylinder storage yards in surface runoff and then migrate through the soil and into groundwater. It was further assumed that public access would be possible for groundwater at the location of the nearest discharge point (i.e., the nearest surface water body in the direction of groundwater flow).

- To address uncertainty in corrosion and cylinder breach assumptions, an assessment was also conducted assuming that external corrosion was not halted by improved maintenance conditions (see Section 3.3 for a discussion of potential impacts).

3.2.1 Human Health — Normal Operations

3.2.1.1 Radiological Impacts

Radiological impacts from normal operations at the K-25 cylinder storage yards were assessed for the involved workers, noninvolved workers, and off-site general public. Radiation exposures of involved workers would result primarily from external radiation from inspecting and handling the cylinders. Exposures of noninvolved workers would result from airborne releases of UO_2F_2 from breached cylinders. In addition to exposures from airborne releases of UO_2F_2, the analysis also considered potential exposures of the off-site public to waterborne releases of UO_2F_2. Such releases would be possible if UO_2F_2 was deposited on the ground surface and washed off by rain to a surface water body or infiltrated with rain to the deeper soil, thereby reaching the groundwater underlying the storage yards. Detailed discussions of the methodologies used in radiological impact analyses are provided in Appendix C the PEIS and Cheng et al. (1997).

The estimated radiation doses and latent cancer risks are provided in Tables 3.4 and 3.5, respectively. During the storage periods, average radiation exposures of involved workers would be less than 410 mrem/yr; exposures of noninvolved workers and members of the general public would be less than 1 mrem/yr. The long-term effects of radiation exposure on the general public resulting from groundwater contamination would be less than 1 mrem/yr. Potential long-term radiological impacts (based on groundwater contamination) are provided in Table 3.6.

The average annual collective worker dose would be about 4.9 person-rem/yr for approximately 13 workers for the period from 1999 through 2039. The average individual dose would be about 410 mrem/yr for this period, considerably below the regulatory limit of 5,000 mrem/yr and the DOE administrative control limit of 2,000 mrem/yr. Exposure of involved workers would be greater than the historical data of 32 to 92 mrem/yr (Hodges 1996) because of more worker activities planned to be implemented. Radiation exposure of noninvolved workers at the K-25 site would be less than 0.048 mrem/yr from airborne release of UO_2F_2.

As a result of the short distance assumed between the emission point and the site boundary, the estimated radiation dose to the MEI of the general public would be greater than the dose to noninvolved workers. Potential exposure of the general public MEI would be less than 0.16 mrem/yr (0.11 mrem/yr from exposure to airborne releases and 0.051 mrem/yr from using contaminated groundwater). The radiation dose from drinking contaminated surface water would be less than 0.000011 mrem/yr. The radiation dose of 0.16 mrem/yr would be less than the existing exposure of approximately 5 mrem/yr from operation of the entire ORR (LMES 1995a). The long-term radiological impacts to the general public from using contaminated groundwater would range from 0.051 to 0.49 mrem/yr, which is very low compared with the dose limit of 100 mrem/yr from all exposure pathways.

TABLE 3.4 Radiological Doses from Continued Cylinder Storage at the K-25 Site under Normal Operations under the No Action Alternative

Annual Dose to Receptor					
Involved Workers[a]		Noninvolved Workers[b]		General Public	
Average Individual Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose[c] (mrem/yr)	Collective Dose[d] (person-rem/yr)	MEI Dose[e] (mrem/yr)	Collective Dose[f] (person-rem/yr)
410	4.9	0.048	0.00021	0.11 (< 0.051)	0.0026

[a] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual dose and collective dose for the worker population. The reported values are averages over the time period 1999–2039. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

[b] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

[c] The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest dose. The reported values are the maximums over the time period considered.

[d] The reported collective doses are averages over the time periods considered. The size of the population of noninvolved workers was assumed to be about 3,500 for the K-25 site.

[e] The MEI for the general public was assumed to be located off-site at a point that would yield the largest dose. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[f] Collective dose was estimated for the population within a radius of 50 miles (80 km) around the site. The reported values are averages over the time period considered. The off-site population is 877,000 for K-25. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

TABLE 3.5 Latent Cancer Risks from Continued Cylinder Storage at the K-25 Site under Normal Operations under the No Action Alternative

Annual Risk of Latent Cancer Fatality to Receptor					
Involved Worker[a]		Noninvolved Worker[b]		General Public	
Average Individual Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk[c] (risk/yr)	Collective Risk[d] (fatalities/yr)	MEI Risk[e] (risk/yr)	Collective Risk[f] (fatalities/yr)
2×10^{-4}	2×10^{-3}	2×10^{-8}	8×10^{-8}	5×10^{-8} ($< 5 \times 10^{-9}$)	1×10^{-6}

[a] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual risk and collective risk for the worker population. The reported values are averages over the time period 1999–2039.

[b] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

[c] The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest risk. The reported values are the maximums over the time period considered.

[d] The reported collective risks are averages over the time period considered. The size of the population of noninvolved workers was assumed to be about 3,500 for the K-25 site.

[e] The MEI for the general public was assumed to be located off-site at a point that would yield the largest risk. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[f] Collective risk was estimated for the population within a radius of 50 miles (80 km) around the site. The reported values are averages over the time period considered. The off-site population is 877,000 for K-25. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

3.2.1.2 Chemical Impacts

Chemical impacts during continued cylinder storage could result primarily from exposure to UO_2F_2 (the product formed when UF_6 is exposed to moist air) and HF released from hypothetical cylinder breaches. Risks from normal operations were quantified on the basis of calculated hazard indexes. Detailed discussions of the exposure assumptions, health effects assumptions, reference doses used for uranium compounds and HF, and calculational methods used in the chemical impact analysis are provided in Appendix C of the PEIS and Cheng et al. (1997).

Hazardous chemical impacts to the MEI were calculated for both noninvolved workers and members of the general public; the results are summarized in Table 3.7. Chemical exposures of noninvolved workers and the off-site general public could result from airborne emissions of UO_2F_2 and HF that could be dispersed from hypothetical cylinder breaches into the atmosphere and to the ground surface. The exposure pathways assessed included inhalation of UO_2F_2 and HF and ingestion of UO_2F_2 in soil. In all cases, the MEI hazard index would be considerably below 1, indicating no potential adverse health effects.

TABLE 3.6 Long-Term Radiological Impacts to Human Health from Continued Cylinder Storage at the K-25 Site under the No Action Alternative[a,b]

Impact to MEI of General Public	
Radiation Dose[c] (mrem/yr)	Latent Cancer Risk[c] (risk/yr)
0.051 - 0.49	$3 \times 10^{-8} – 2 \times 10^{-7}$

[a] The long-term impacts correspond to the time after the year 2039.

[b] Long-term impacts would be caused by the potential use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock. Contamination of groundwater would result from releases from hypothetically breached cylinders and the resulting infiltration of UO_2F_2 to the deeper soils, eventually reaching the groundwater (UO_2F_2 is the product of UF_6 reacting with moisture in air).

[c] Radiation doses and latent cancer risks are expressed as ranges, which would result from different transport speeds of uranium in soil. The reported values are the maximum values that would occur after 2039, assuming no mitigation action was taken.

3.2.2 Human Health — Accident Conditions

A range of accidents covering the spectrum of high-frequency/low-consequence accidents to low-frequency/high-consequence accidents was presented in the SARs for the three storage sites (LMES 1997a,e,f). The potential accidents discussed in the SARs included natural phenomena events such as earthquakes, tornadoes, and floods, and spills from corroded cylinders under various weather conditions. The accidents selected for analysis for the PEIS and this report were those accident scenarios in the SARs that resulted in the greatest potential consequences for each of the four frequency categories (likely, unlikely, extremely unlikely, and incredible); these accidents are listed in Table 3.8. The accidents do not include natural phenomena events, which were found in the

TABLE 3.7 Chemical Impacts to Human Health from Continued Cylinder Storage at the K-25 Site under Normal Operations under the No Action Alternative

	Impacts to Receptor			
	Noninvolved Workers[a]		General Public[b]	
Time Period	Hazard Index[c] for MEI	Population Risk[d] (ind. at risk/yr)	Hazard Index[c] for MEI	Population Risk[d] (ind. at risk/yr)
1999–2039	4.8×10^{-4}	–	2.3×10^{-2} (# 6.4×10^{-3})	–
Long-term[e]	NA[f]	–	0.01 – 0.06	–

[a] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. The MEI for the noninvolved worker was assumed to be at the on-site (outside storage yards) location that would yield the largest exposure. Exposures would result from airborne emissions of UO_2F_2 and HF from hypothetically breached cylinders; the exposure pathways considered included inhalation and incidental ingestion of soil.

[b] The MEI for the general public was assumed to be located off-site at the point that would yield the largest exposure. Results reported are the maximum values over the time period considered and would result from exposure via inhalation; ingestion of soil (resulting from airborne emissions of UO_2F_2 and HF from hypothetically breached cylinders); and drinking surface water (consequence of the discharge of contaminated runoff water to a surface water body). Potential impacts during the storage period 1999–2039 (values within parentheses) were also evaluated from the use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[c] The hazard index is an indicator for potential health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation.

[d] Calculation of population risk is not applicable when the corresponding hazard index for the MEI is less than 1.

[e] Long-term impacts would result from using contaminated groundwater. Ranges result from different transport speeds of uranium in soil. The reported values are the maximum values that would occur after 2039, assuming no mitigative measures were taken.

[f] NA = not applicable; workers were assumed not to ingest groundwater.

TABLE 3.8 Accidents Considered for the Continued Storage Option at the K-25 Site

Site/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Vehicle-induced fire, 3 full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Incredible Accidents (frequency: less than 1 in 1 million years)					
Small plane crash, 2 full 48G cylinders	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,190	0 to 30 30 to 121	Ground

[a] Ground-level releases were assumed to occur outdoors on the concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

SARs to have less serious consequences than other types of accident scenarios (e.g., a vehicle-induced fire affecting three UF_6 cylinders). In those instances where it was not absolutely clear from the SAR which accident would be the bounding accident in a frequency category, several accidents were included in the analyses, as indicated in Table 3.8. The resulting radiological doses and adverse health impacts from chemical exposures for all the accidents listed in Table 3.8 are presented in Policastro et al. (1997). In the following sections, the results for only the bounding accident in each frequency category are presented. Detailed descriptions of the methodology and assumptions used in these calculations are provided in Appendix C of the PEIS and Policastro et al. (1997).

3.2.2.1 Radiological Impacts

Table 3.9 lists the radiological doses to various receptors for the accidents that give the highest dose from each frequency category. The LCF risks for these accidents are given in Table 3.10. The doses and the risks are presented for two different meteorological conditions (D and

TABLE 3.9 Estimated Radiological Doses per Accident Occurrence for Continued Cylinder Storage at the K-25 Site under the No Action Alternative

		Maximum Dose[c]				Minimum Dose[c]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Accident[a]	Frequency Category[b]	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	1.3	2.7×10^{-3}	4.3×10^{-1}	3.3×10^{-3}	6.0×10^{-2}	1.1×10^{-4}	5.9×10^{-2}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.6×10^{1}	1.3×10^{-2}	6.3×10^{1}	3.7×10^{-3}	2.4	1.9×10^{-3}	2.2
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	5.4	4.3×10^{-3}	7.4×10^{-1}	8.7×10^{-4}	6.9×10^{-1}	7.1×10^{-4}	1.0×10^{-1}

[a] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[b] Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} – 10^{-4}/yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} – 10^{-6}/yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations (< 10^{-6}/yr).

[c] Maximum and minimum doses reflect differences in assumed meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed. An exception is the vehicle-induced fire involving 3 full 48G cylinders, which would result in a higher population dose for the general public under D stability with 4 m/s wind speed.

TABLE 3.10 Estimated Radiological Health Risks per Accident Occurrence for Continued Cylinder Storage at the K-25 Site under the No Action Alternative[a]

		Maximum Risk[d] (LCFs)				Minimum Risk[d] (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Accident[b]	Frequency Category[c]	MEI	Population	MEI	Population	MEI	Population	MEI	Population
Corroded cylinder spill, dry conditions	L	3×10^{-5}	5×10^{-4}	1×10^{-6}	2×10^{-4}	1×10^{-6}	2×10^{-5}	6×10^{-8}	3×10^{-5}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	7×10^{-6}	3×10^{-2}	1×10^{-6}	9×10^{-4}	1×10^{-6}	1×10^{-3}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	2×10^{-3}	2×10^{-6}	4×10^{-4}	3×10^{-7}	3×10^{-4}	4×10^{-7}	5×10^{-5}

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCF) times the estimated frequency times the number of years of operations (41 for the no action alternative). The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} – 10^{-4}/yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} – 10^{-6}/yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations (< 10^{-6}/yr).

[d] Maximum and minimum risks reflect differences in assumed meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed. An exception is the vehicle-induced fire involving 3 full 48G cylinders, which would result in a higher population dose for the general public under D stability with 4 m/s wind speed.

F stability classes) (see Appendix C of the PEIS). The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely (EU) category have a probability of occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.

- The maximum radiological dose to worker and general public MEIs (assuming that an accident occurred) would be 0.077 rem. This dose is less than the 25-rem dose recommended by the U.S. Nuclear Regulatory Commission (NRC 1994) specified for assessing the adequacy of protection of public health and safety from potential accidents.

- The overall radiological risk to worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table 3.10] by the annual probability of occurrence by the number of years of operations) would be less than 1 for all of the continued storage accidents.

3.2.2.2 Chemical Impacts

The accidents discussed in this section are listed in Table 3.8. The results of the accident consequence modeling in terms of chemical impacts are presented in Tables 3.11 and 3.12. The results are presented as (1) number of persons with the potential for adverse effects and (2) number of persons with the potential for irreversible adverse effects. The tables present the results for the accident within each frequency category that would affect the largest number of people (total of workers and off-site population) (Policastro et al. 1997). The impacts presented are based on the assumption that the accidents would occur. The accidents listed in Tables 3.11 and 3.12 are not identical because an accident with the largest impacts for the adverse effects endpoint might not lead to the largest impacts for the irreversible adverse effects endpoint. Detailed descriptions of the methodology and assumptions for assessing chemical impacts are provided in Appendix C of the PEIS. The following conclusions may be drawn from the chemical impact results:

- If the accidents identified in Tables 3.11 and 3.12 did occur, the number of persons in the off-site population with the potential for adverse effects would range from 0 to 550 (maximum corresponding to the vehicle-induced fire scenario) and the number of off-site persons with potential for irreversible adverse effects would be zero.

TABLE 3.11 Number of Persons with Potential for Adverse Effects from Accidents under Continued Cylinder Storage at the K-25 Site under the No Action Alternative[a]

		Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Accident[b]	Frequency Category[c]	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Corroded cylinder spill, dry conditions	L	Yes	69	No	0	Yes[f]	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	700	Yes	18	Yes	47	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	770	Yes	550	No	0	Yes	12
Small plane crash, 2 full 48G cylinders	I	Yes	420	Yes	34	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times the number of years of operations (41 for the no action alternative). The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} – 10^{-4}/yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} – 10^{-6}/yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations (< 10^{-6}/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum risks would occur under the meteorological condition of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either “Yes” or “No” for potential adverse effects to an individual.

[f] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

TABLE 3.12 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under Continued Cylinder Storage at the K-25 Site under the No Action Alternative[a]

		Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Accident[b]	Frequency Category[c]	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Corroded cylinder spill, dry conditions	L	Yes	3	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	140	Yes[f]	0	Yes	2	No	0
Vehicle-induced fire, 3 full 48Y cylinders[g]	EU	No	0	No	0	No	0	No	0
Small plane crash, 2 full 48G cylinders[g]	I	No	0	No	0	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times the number of years of operations (41 for the no action alternative). The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} – 10^{-4}/yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} – 10^{-6}/yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations (< 10^{-6}/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum risks would occur under the meteorological condition of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either “Yes” or “No” for potential irreversible adverse effects to an individual.

[f] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

[g] These accidents would result in the largest plume sizes, although no people would be affected.

- If the accidents identified in Tables 3.11 and 3.12 did occur, the number of noninvolved workers with the potential for adverse effects would range from 0 to 770 (maximum corresponding to the vehicle-induced fire scenario), and the number of noninvolved workers with the potential for irreversible adverse effects would range from 0 to 140 (maximum corresponding to the corroded cylinder spill under wet conditions scenario).

- Accidents resulting in a vehicle-induced fire involving three full 48G cylinders during very stable (nighttime) meteorological conditions would have a very low probability of occurrence but could affect a large number of people.

- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years of operations (41 years, 1999–2039). The results indicate that the maximum risk values would be less than 1 for all accidents, except the following:

  - *Potential Adverse Effects:*

    Corroded cylinder spill, dry conditions (L, likely), workers

    Corroded cylinder spill, wet conditions – rain (U, unlikely), workers

  - *Potential Irreversible Adverse Effects:*

    Corroded cylinder spill, dry conditions (L, likely), workers

    Corroded cylinder spill, wet conditions – rain (U, unlikely), workers

These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated potential irreversible adverse effects was estimated. All the bounding case accidents shown in Table 3.12 would involve releases of UF_6 and potential exposure to HF and uranium compounds. These exposures would likely be high enough to result in death for 1% or less of the persons experiencing irreversible adverse effects (Policastro et al. 1997). This would mean that for workers experiencing a range of 0 to 140 irreversible adverse effects, approximately 0 to 1 death would be expected. This is the maximum potential consequence of the accident; the upper end of the range assumes worst-case weather conditions and that the wind would be blowing in the direction where the highest number of people would be exposed.

3.2.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries for workers (involved and noninvolved) conducting activities associated with continued storage was calculated using industry-specific statistics from the U.S. Bureau of Labor Statistics, as reported by the National Safety Council (1995). Annual fatality and injury rates for manufacturing activities were used for all activities except cylinder yard construction or reconstruction; rates specific to construction were available for these activities. Injury incidence rates used were for injuries involving lost workdays (not including the day of injury).

The activities included as part of the continued storage strategy are routine cylinder inspections, ultrasonic inspections, valve monitoring and maintenance activities, cylinder relocations, cylinder yard construction or reconstruction, cylinder painting, and patching and content transfers for breached cylinders (Parks 1997). These activities were assumed to be continued at currently planned levels through the year 2039, except for yard construction and reconstruction, which were assumed to be completed by the year 2003. The annual labor requirements and the corresponding fatality and injury risks for these activities were estimated to be as follows: the fatality risk would be less than 1 (0.026), and the injury risk would be about 33 injuries.

3.2.3 Air Quality

The analysis of air quality impacts for continued cylinder storage under the no action alternative was based on three emissions-producing activities: (1) construction of new storage yards; (2) relocation and painting of cylinders; and (3) estimated HF emissions resulting from hypothetical cylinder breaches. The air quality impacts of these three activities at the K-25 site are addressed in this section. Additional details on the assessment of air quality impacts are presented in Tschanz (1997a,b).

The maximum estimated criteria pollutant concentrations at the K-25 boundary during yard construction are shown in Table 3.13. These maximum concentrations would occur when the planned new storage yard would be completed. The maximum monitored 24-hour PM_{10} concentration at the Y-12 site is about 29 $\mu g/m^3$, which when added to the estimated maximum PM_{10} concentration at the K-25 site brings the total above the 150 $\mu g/m^3$ standard.

TABLE 3.13 Maximum Concentrations of Criteria Pollutants at K-25 Site Boundaries during Yard Construction[a]

	Estimated Maximum Criteria Pollutants							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concen-tration (: g/m^3)	Fraction of Standard[b]	Concen-tration (: g/m^3)	Fraction of Standard[b]	Concen-tration (: g/m^3)	Fraction of Standard[b]	Concen-tration (: g/m^3)	Fraction of Standard[b]
CO	266	0.0067	122	0.012	41.1	–	7.66	–
HC[c]	27.3	–	12.5	–	4.22	–	0.787	–
NO_x	103	–	47.1	–	15.9	–	2.97	0.03
SO_x	10.9	–	5.00	–	1.69	–	0.315	0.004
PM_{10}	930	–	425	–	144	0.96	26.8	0.54

[a] Values are based on construction of a new yard assumed to be located at the site of the current K-yard. CO = carbon monoxide, HC = hydrocarbons, NO_x = nitrogen oxides, SO_x = sulfur oxides, PM_{10} = particulate matter with a diameter of 10 : m or less.

[b] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded.

[c] HC, although not a criteria pollutant, was used to evaluate potential impacts to the criteria pollutant ozone.

The construction fugitive dust emissions used here were based on a general emission factor that considers only the size of the disturbed area and might be an overestimate for the actual use of construction equipment on the site. Detailed information about the planned construction would be required to more accurately assess the actual likely impacts. It is likely that some measures to reduce the generation of fugitive dust during yard construction would be necessary. All other criteria pollutant concentrations at K-25 would be well below their respective standards, generally being between 1 to 3% of the standard. For years during which no construction activities are planned, the maximum pollutant concentrations should not exceed air quality standards (Tables 3.14 and 3.15).

The maximum annual and 24-hour average HF concentrations from hypothetical cylinder breaches at K-25 are shown in Table 3.16 (Tschanz 1997b). These concentrations are a result of the distance to the nearest facility boundary from the modeled location. The estimated maximum 24-hour HF concentration would be 0.66 : g/m^3, which is 23% of the State of Tennessee standard of 2.9 : g/m^3. The highest monitored 7-day HF concentration at the Y-12 site in 1992 was 0.28 : g/m^3.

No quantitative estimate was made of the impacts on the criteria pollutant ozone. Formation of O_3 is a regional issue affected by emissions data for the entire area around the K-25 site. Anderson

TABLE 3.14 Maximum Concentrations of Criteria Pollutants at K-25 Site Boundaries due to Cylinder Relocations[a]

	Estimated Maximum Criteria Pollutants							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concen-tration (: g/m^3)	Fraction of Standard[b]	Concen-tration (: g/m^3)	Fraction of Standard[b]	Concen-tration (: g/m^3)	Fraction of Standard[b]	Concen-tration (: g/m^3)	Fraction of Standard[b]
CO	5.36	0.00013	1.40	0.00014	0.469	–	0.0277	–
HC[c]	0.434	–	0.113	–	0.0379	–	0.00224	–
NO_x	0.643	–	0.168	–	0.0562	–	0.00332	0.00003
SO_x	1.55	–	0.405	–	0.136	–	0.00803	0.0001
PM_{10}	0.136	–	0.0356	–	0.0119	0.00008	0.000705	0.00001

[a] Cylinder relocations are planned during the time frame considered (1999–2039). CO = carbon monoxide, HC = hydrocarbons, NO_x = nitrogen oxides, SO_x = sulfur oxides, PM_{10} = particulate matter with a diameter of 10 : m or less.

[b] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded.

[c] HC, although not a criteria pollutant, was used to evaluate potential impacts to the criteria pollutant ozone.

TABLE 3.15 Maximum Concentrations of Criteria Pollutants at K-25 Site Boundaries due to Cylinder Painting[a]

	Estimated Maximum Criteria Pollutants							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concen-tration (: g/m^3)	Fraction of Standard[b]	Concen-tration (: g/m^3)	Fraction of Standard[b]	Concen-tration (: g/m^3)	Fraction of Standard[b]	Concen-tration (: g/m^3)	Fraction of Standard[b]
CO	2.75	0.000069	0.716	0.000072	0.240	–	0.014	–
HC[c]	36.8	–	9.59	–	3.22	–	0.190	–
NO_x	0.321	–	0.084	–	0.028	–	0.0017	0.000017
SO_x	0.803	–	0.209	–	0.070	–	0.0042	0.000054
PM_{10}	0.064	–	0.017	–	0.0056	0.000037	0.00033	0.0000066

[a] Maximum pollutant concentrations are based on the assumed maximum number of cylinders painted annually under the no action alternative: 1,200 at K-25. CO = carbon monoxide, HC = hydrocarbons, NO_x = nitrogen oxides, SO_x = sulfur oxides, PM_{10} = particulate matter with a diameter of 10 : m or less.

[b] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded.

[c] HC, although not a criteria pollutant, was used to evaluate potential impacts to the criteria pollutant ozone.

TABLE 3.16 Estimated Number of Breached Cylinders, Maximum HF Emissions, and Average Maximum HF Concentrations at the K-25 Site under the No Action Alternative

Maximum Number of Breaches Starting in a Single Year	Maximum Total Number of Active Breaches in a Single Year	Maximum HF Concentration (: g/m^3)	
		24-Hour Average	Annual Average
1	2	0.66	0.084

and Roane Counties in the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Region are currently in attainment for all criteria pollutant standards, including O_3. The pollutant emissions most related to O_3 formation that could result from the continued storage options at the K-25 site would be hydrocarbons (HC) and NO_x. The potential effects on O_3 of those pollutants can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in Anderson and Roane Counties, as recorded in the Tennessee Division of Air Pollution Control "Emissions Inventory" for 1995 (Conley 1996). The estimated HC and NO_x emissions of 3.03 and 1.24 tons/yr would be only 0.11 and 0.002%, respectively, of the 1995 two-county emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the O_3 attainment status of the region. The HC and NO_x emissions would be even smaller during later continued storage periods.

3.2.4 Water and Soil

Potential water and soil impacts for continued storage of cylinders under the no action alternative were evaluated for surface water, groundwater, and soils at the facility. Impacts to water and soil quality were evaluated by comparisons with EPA guidelines.

Water use for construction under the no action alternative was estimated to be 0.81 million gal. Operational water use was estimated as ranging from 0.025 to 0.032 million gal/yr at K-25.

3.2.4.1 Surface Water

The estimated number of cylinder breaches assumed to occur under the no action alternative is given in Table 3.1; these estimates were used to calculate potential impacts to surface water quality. Each breached cylinder was assumed to release a maximum of 4 lb (1.8 kg) of uranium over a period of 4 years; additional details on the methodology used to evaluate the impacts are given in Appendix C of the PEIS and Tomasko (1997b).

The estimated maximum uranium concentrations in runoff water leaving the yards would be about 52 : g/L (13 pCi/L). This concentration would occur in about 2002. The contaminated runoff was then assumed to flow without loss to the nearest surface water, where it would mix and be diluted. For average flow conditions, the dilution would be large enough that the maximum concentrations would be less than 0.1 : g/L (0.03 pCi/L) (Table 3.17). This concentration is less than the EPA proposed drinking water maximum contaminant level (MCL) for uranium of 20 : g/L, used here for comparison. The contaminated water would then mix with water in the Clinch River, resulting in more dilution. Because of this mixing, impacts to the major rivers would not be measurable.

3.2.4.2 Groundwater

Groundwater impacts were assessed by assuming that water contaminated due to releases from hypothetical cylinder breaches would leave the yards as runoff and flow to the boundary of the nearest surface water (but not discharge to it), thereby creating a contaminated source on the ground surface. Under the no action alternative, the only impacts to groundwater would be to water quality; no impacts would occur to recharge, depth to water, or direction of flow (see Section 3.3 for discussion of potential impacts based on assuming a greater number of breaches). Conservative estimates of the concentration of uranium in groundwater were obtained by assuming the surface value to be equal to the maximum concentration in water leaving each yard during a time interval of approximately 40 years. This duration corresponds to the time period for the no action alternative. Details on the methodology are given in Appendix C of the PEIS and Tomasko (1997b).

At the end of the no action period (2039), the concentration of uranium in groundwater directly below the edge of the surface contamination at the K-25 site was estimated to be about 0.6 : g/L (Table 3.18), for a retardation factor of 5 (Tomasko 1997b). This concentration is less than the EPA proposed drinking water MCL for uranium of 20 : g/L (EPA 1996), used here for comparison. A maximum concentration of 7 : g/L would occur at the site between 2070 and 2090 (Table 3.18). For a retardation factor of 50 (relatively immobile uranium transport), the maximum concentration would be about 10 times less.

TABLE 3.17 Maximum Uranium Concentrations in Surface Waters for Continued Cylinder Storage at the K-25 Site under the No Action Alternative

Receiving Water	Dilution Factor	Maximum Concentration (: g/L)
Poplar Creek	2,550	0.02
Clinch River	94	0.0002

TABLE 3.18 Groundwater Concentrations for Continued Cylinder Storage at the K-25 Site for Two Soil Characteristics under the No Action Alternative[a]

	X = 0			X = 1,000 ft		
	Concentration		Time at Maximum Concentration	Concentration		Time at Maximum Concentration
Parameter	pCi/L	:g/L		pCi/L	:g/L	
Retardation Factor = 5						
Concentration at 40 years	0.2	0.60				
Maximum concentration	2	7.3	60 years	1.5	5.7	80 years
Retardation Factor = 50						
Maximum concentration	0.2	0.8	500 years	0.2	0.6	675 years

[a] Retardation factors describe how readily a contaminant such as uranium moves through the soil in groundwater. A retardation factor of 5 represents a case in which the uranium moves relatively rapidly in the soil; a retardation factor of 50 represents a case in which uranium moves slowly.

3.2.4.3 Soil

The estimated number of cylinder breaches assumed to occur under the no action alternative was used to calculate impacts to soil quality. Each breached cylinder was assumed to release a maximum of 1 lb/yr (0.45 kg/yr) for a maximum of 4 years. For soil, the only impacts would be to quality; there would be no impacts to topography, permeability, or erosion potential. Details on these calculations and methodology are presented in Appendix C of the PEIS and Tomasko (1997b).

The highest soil concentration of uranium would be 0.3 :g/g in about 2002 for a distribution coefficient of 5 (relatively low sorption capacity). If the soil had a larger sorption capacity (K_d = 50), the maximum value would be 3.0 :g/g. Even with the larger sorption, soil concentrations at the three sites would be below the recommended EPA guidelines of 230 :g/g for residential soil and 6,100 :g/g for industrial soil (EPA 1995).

3.2.5 Socioeconomics

The impacts of continued storage on regional economic activity were estimated for an ROI around the K-25 site. Additional details regarding the assessment methodology are presented in Appendix C of the PEIS and Allison and Folga (1997).

Current storage activities at the site would likely have a small impact on socioeconomic conditions in the ROI surrounding the site (see Section 2.8) This is partly because a major proportion of expenditures associated with procurement for conducting continued storage activities would flow outside the ROI to other locations in the United States, thereby reducing the concentration of local economic effects of current storage activities at the site.

Slight changes in employment and income would occur in the ROI as a result of local spending derived from employee wages and salaries, local procurement of goods and services required to conduct continued storage activities, and other local investments associated with construction and operations. In addition to creating new (direct) jobs at the site, continued storage would also create indirect employment and income in the ROI as a result of jobs and procurement expenditures at the site. Jobs and income created directly by continued storage, together with indirect activity in the ROI, would contribute slightly to a reduction in unemployment in the ROI surrounding the site. Minimal impacts would be expected on local population growth and, consequently, on local housing markets and local fiscal conditions.

The effects of continued cylinder storage activities on regional economic activity, measured in terms of employment and personal income, and on population, housing, and local public revenues and expenditures at the K-25 site are discussed in this section. Impacts are presented for the peak year of construction and the peak year of operations. The potential impacts of continued cylinder storage are shown in Table 3.19.

In the single year during which construction activities are planned at the K-25 site, 10 direct jobs would be created at the site and 50 additional jobs indirectly in the ROI (Table 3.19) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 60 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with $1.5 million in income produced during the year. During the peak year of continued cylinder storage activities, 90 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, for a total income of $3.7 million. Continued cylinder storage activities would result in an increase of less than 0.001 percentage point in the projected baseline compound annual average growth rate in ROI employment from 1999 through 2039.

Construction activities would be expected to generate direct in-migration of 10 in the construction year (Table 3.19). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to 20 in the peak year. Continued cylinder storage activities would be expected to generate direct and indirect job in-migration of 30 in the peak year of operations and would result in an increase of less than 0.001 percentage point in the projected baseline compound annual average growth rate in the ROI population from 1999 through 2039.

TABLE 3.19 Potential Socioeconomic Impacts of Continued Cylinder Storage at the K-25 Site under the No Action Alternative

Parameter	Impacts from Construction[a]	Impacts from Operations[b]
Economic activity in the ROI		
Direct jobs	10	30
Indirect jobs	50	50
Total jobs	60	90
Income ($ million)		
Direct income	0.4	2.7
Total income	1.5	3.7
Population in-migration into the ROI	20	30
Housing demand		
Number of units in the ROI	10	10
Public finances		
Change in ROI fiscal balance (%)	0.0	0.0

[a] Impacts for peak construction year. Construction activities were assumed to occur over 1 year (Parks 1997).

[b] Impacts for peak year of operations. Duration of operations was assumed to be 41 years (1999–2039).

Continued cylinder storage activities would generate the demand for 10 additional rental housing units during the construction year and would represent an impact of 0.2% on the projected number of vacant rental housing units in the ROI (Table 3.19). The demand for 10 additional owner-occupied housing units would be expected in the peak year of operations and would represent an impact of 0.1% on the number of vacant owner-occupied housing units.

During construction, 20 persons would in-migrate into the ROI, which would lead to an increase of less than 0.1% over ROI-forecasted baseline revenues and expenditures (Table 3.19). In the peak year of operations, 30 in-migrants would be expected, which would result in a 0.01% increase in local revenues and expenditures.

3.2.6 Ecology

Impacts to ecological resources during continued cylinder storage would be expected to be negligible. Analysis of potential impacts was based on exposure to airborne contaminants or contaminants released to soil, groundwater, or surface water. Predicted concentrations of contaminants in environmental media were compared to benchmark values of toxic and radiological effects to assess impacts to terrestrial and aquatic biota. A detailed discussion of assessment methodology is presented in Appendix C of the PEIS.

Atmospheric emissions of criteria pollutants from cylinder painting, cylinder relocation, and new yard construction would be well below levels harmful to biota, and impacts to ecological resources would be negligible. (See Section 3.2.3 for a discussion of air quality impacts.)

The maximum annual average air concentration of HF at the site boundary, due to hypothetical cylinder breaches, would be very low, up to 0.08 μg/m^3 (Section 3.2.3). Resulting impacts to biota would be expected to be negligible. Potential impacts to ecological resources are shown in Table 3.20.

Soil near the storage yards could become contaminated with uranium by surface runoff from the yards. Uptake of uranium-containing compounds can cause adverse effects to vegetation. The potential maximum uranium concentration in soil would be 3.0 μg/g (Section 3.2.4.3). Because this estimated concentration is below the lowest concentration known to produce toxic effects in plants, toxic effects on vegetation due to uranium uptake would not be expected (Table 3.20).

Surface runoff from the storage yards would result in a maximum (undiluted) uranium concentration of 52 μg/L (13.4 pCi/L) at the site (Section 3.2.4.1). Resulting dose rates to maximally exposed organisms in the nearest receiving surface water body at each site would be negligible. The uranium concentration is also considerably below 150 μg/L, which is the lowest concentration known to adversely affect aquatic biota. Therefore, impacts to aquatic biota would not be expected.

Surface runoff from the storage yards could infiltrate adjacent soil and become a source of groundwater contamination. Groundwater could discharge to the surface (such as in wetland areas) near the facility, thus exposing biota to contaminants. The groundwater concentration of uranium near the storage yards could range up to 7.3 μg/L; uranium activity could range up to 2 pCi/L (Section 3.2.4.2). Resulting toxic effects and dose rates to maximally exposed organisms would be negligible. Resulting impacts to aquatic biota would therefore be negligible (Table 3.20).

Facility accidents (Section 3.2.2) could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors, such as location of the accident, season, and meteorological conditions.

TABLE 3.20 Potential Impacts to Ecological Resources from Continued Cylinder Storage at the K-25 Site under the No Action Alternative

Contaminant	Biota	Maximum Exposure	Effect
Hydrogen fluoride	Wildlife	0.08 : g/m^3	Negligible
Uranium in surface water	Aquatic	52 : g/L 13 pCi/L	Negligible Negligible
Uranium in groundwater	Aquatic	7.3 : g/L 1.9 pCi/L	Negligible Negligible
Uranium in soil	Plants	3.0 : g/g	Negligible

3.2.7 Waste Management

The principal wastes expected to be generated by operations involving continued cylinder storage are LLW and LLMW. Impacts on waste management from wastes generated during the continued storage operations would be caused by the potential overload of waste treatment and/or disposal capabilities either at a site or on a regional/national scale. Total waste generated at the site from continued cylinder storage under the no action alternative is listed in Table 3.21. Given the types and quantities of waste expected to be generated, there is little potential for impacts on regional or national waste treatment/disposal capabilities.

Only limited construction of additional facilities would be needed to support the operations involved in the continued storage and maintenance of cylinders. No waste management impacts resulting from construction-generated wastes would be expected.

The normal operations to maintain and store cylinders would consist of inspections, stripping and repainting of the cylinders, and disposal of scrap metal from breached cylinders that required emptying. These operations would generate two primary waste streams: (1) uranium-contaminated scrap metal LLW from breached cylinders and failed valves and (2) solid process residue LLMW from cylinder painting. In the event of cylinder failure, small amounts of additional LLMW could be generated due to releases from breached cylinders.

The amount of LLW generated from continued storage would at most represent less than 1% of site LLW generation (see Section 2.9). The maximum annual amount of LLW generated during the continued storage of cylinders would represent less than 1% of the annual DOE LLW generation.

Continued storage would also generate LLMW. At the K-25 site, continued cylinder storage would generate less than 1% of the total LLMW load at ORR. Overall, the waste input resulting from continued cylinder storage would have negligible impacts on waste management capabilities at the K-25 site. Impacts on national waste management capabilities would be negligible. The input of LLMW from continued cylinder storage would represent less than 1% of the total nationwide LLMW load.

TABLE 3.21 Waste Generated during Continued Cylinder Storage under the No Action Alternative (1999–2039)

Waste (m^3)	
LLW[a]	LLMW[b]
10	157

[a] Contaminated scrap metal from breached cylinders that would require emptying.

[b] Inorganic process residues from cylinder painting.

3.2.8 Resource Requirements

The approach taken to assess resource requirements was based on a comparison of required resources with national and state-level statistics on consumption of commodities (U.S. Department of Commerce 1997, 1999). More detailed information related to the methodology is presented in Appendix C of the PEIS.

Material resources that could be consumed during continued cylinder storage include construction materials that could not be recovered or recycled, and materials consumed or reduced to unrecoverable forms of waste. Where construction is necessary, materials required could include concrete, sand, gravel, steel, and other metals. In general, none of the construction resources identified for continued cylinder storage are in short supply, and all would be readily available in the vicinity of the three sites. Energy resources during construction and operations would include the consumption of diesel fuel and gasoline for construction equipment and transportation vehicles. The anticipated utilities requirements would be within the supply capacities at the site.

Continued cylinder storage would require materials such as 55-gal drums for containment of any generated waste, replacement cylinder valves for those found to be defective upon inspection, and diesel fuel and gasoline to operate equipment and on-site vehicles. In addition, 2 gal of paint per cylinder would be required for cylinder painting. Potable water would be made available for the needs of the workforce.

Materials and utilities required for construction and operation activities for continued storage are presented in Table 3.22. The total quantities of commonly used construction materials are expected to be small compared to local sources. No strategic and critical materials are projected to be consumed for either construction or operations. Small amounts of diesel fuel and gasoline are projected to be used. The required material resources during operations would be readily available.

3.2.9 Land Use

Although no location has been chosen for a new storage yard at K-25, the areal requirement of 6.7 acres (2.7 ha) would be very small and represent less than 1% of the land available for development on the site. Because the yard would likely be located in an area already dedicated to similar use, immediate access to infrastructure and utility support would be possible with only minor disturbances to existing land use. During continued cylinder storage operations, land-use impacts would be negligible and limited to potential minor disruptions on land parcels contiguous to the existing yards. No impacts would be expected for off-site land use.

TABLE 3.22 Resource Requirements of Construction and Operations for Continued Cylinder Storage under the No Action Alternative

Material/Resource	Consumption during 1999–2039
Construction	
Solids	
Concrete (yd^3)	8,000
Construction aggregate (yd^3)	12,000
Special coatings (yd^2)	36,000
Liquids (gal)	
Gasoline	1,300
Diesel fuel	7,300
Operations[a]	
Solids	
55-gal drums (each)	18 – 20
Cylinder valves (1-in.) (each)	2
Liquids (gal/yr)	
Gasoline	700 – 1,000
Diesel fuel	1,500 – 2,600
Zinc-based paint	1,000 – 1,100

[a] Values reported as ranges generally correspond to varying resource requirements during years for which activities are planned.

3.2.10 Cultural Resources

A new storage yard is proposed at the K-25 site; however, the exact location is unknown. Impacts might result if the storage yard is constructed on or near an eligible resource.

3.2.11 Environmental Justice

The analysis of potential environmental justice impacts resulting from continued cylinder storage is based on the conclusions drawn in the assessment of impacts on human health (Sections 3.2.1 and 3.2.2) and a review of environmental impacts presented in discussions of other technical areas (Sections 3.2.3 through 3.2.10) such as air quality, water quality and soils, socioeconomics, and ecological resources. The analysis of health effects included an examination of risks to the general public associated with normal facility operations and accidents. A detailed description of the mapping procedures, screening criteria, calculational methods, and demographic sector analysis is presented in Appendix C, Section C.8, of the PEIS.

Events occurring after 2039 could not be included in the analysis of potential environmental justice impacts because the composition of the population residing within 50 miles (80 km) of a site cannot be projected with accuracy over the long term. Current minority and low-income population proportions for the site were assumed out to the year 2039.

A review of potential human health impacts (Sections 3.2.1 and 3.2.2) indicated that no high and adverse human health effects or impacts would be expected from continued storage of cylinders at the site. Therefore, although minority and low-income populations reside within 50 miles (80 km) of the site, no disproportionate impacts would be expected. The distributions of minority and low-income population census tracts within a 50-mile (80-km) radius of each site are shown in Figure 2.4. Screening criteria limits (Appendix C, Section C.8, of the PEIS) for radiological and chemical sources under normal operations and accident conditions were not exceeded, and the risk of fatalities from operations and accidents from 1999 through 2039 would be considerably below one. Radiological releases from normal operations would result in annual average doses to the MEI residing outside the facilities that would be considerably below the DOE regulatory limit of 100 mrem/yr for members of the public. Chemical impacts from routine operations under continued storage would result in MEI hazard indices well below 1. Additionally, accidental chemical releases would not result in any expected fatalities or expected adverse human health effects for the general public (when considering risk, i.e., the product of the potential number of persons affected and the probability of the accident occurring).

A review of impact assessments for other technical areas (Sections 3.2.3 through 3.2.10) indicated that few or no impacts would be expected from continued storage of cylinders. Projected air emissions from construction activities and operations would be below federal and state regulatory limits and no impacts to water quality or soils are anticipated. Consequently, no segment of the population, including minorities or persons of low income, would experience disproportionate impacts.

3.2.12 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur as a result of continued storage of depleted UF_6 cylinders include impacts to the visual environment (e.g., aesthetics), recreational resources, and noise levels, as well as impacts associated with decontamination and decommissioning of the storage yards. These impacts, although considered, were not analyzed in detail because the impacts would be negligibly small or consideration of the impacts would not contribute to differentiation among the alternatives and therefore would not affect the decisions to be made in the ROD for the PEIS.

3.3 POTENTIAL IMPACTS OF CONTINUED CYLINDER STORAGE BASED ON UNCERTAINTIES IN CORROSION CONTROL

Under the no action alternative, it was assumed that cylinders would be painted every 10 years and that the paint would effectively stop any further corrosion of the cylinders (see introduction to Section 3). To address uncertainty in both the effectiveness of the painting in controlling further corrosion and uncertainties in the future painting schedule, a conservative assessment was made of the impacts assuming that painting would have no effect on corrosion. Under this assumption and using historical data from the site, the number of breaches that would occur at the site as a function of time were estimated (Lyon 1997). These conservative estimates indicate that the number of breaches that could occur prior to 2039 would be about 210 at K-25 (see Table 3.2).

If no credit were taken for corrosion reduction through painting, and if storage was continued indefinitely, calculations indicate that uranium releases from breaches occurring at the K-25 site prior to about the year 2025 could result in a sufficient amount of uranium in the soil column to bring the groundwater concentration of uranium to 20 : g/L in the future (about 2100) (Tomasko 1997a). The groundwater concentration would not actually reach 20 : g/L at the site until about 2100 or later.

Also, if no credit were taken for corrosion reduction through painting, air quality concerns might arise. Calculations indicate that breaches occurring at the K-25 site by around the year 2020 could result in maximum 24-hour average HF concentrations at the site boundary approximately equal to 2.9 : g/m^3 (3.5 parts per billion or ppb). This level corresponds to the primary standard for the State of Tennessee.

A painting program for the cylinders, designed to control further corrosion, has been initiated at the site. Therefore, the assumption of uncontrolled corrosion is not a reasonable assumption. The painting program is expected to eliminate or substantially reduce the corrosion of cylinders at the site. DOE will continue to monitor its cylinders and is committed to maintain the safety basis of continued cylinder storage. If the conditions became substantially different from what is assumed under the no action alternative, DOE would take the appropriate action(s) to maintain the safety basis.

3.4 POTENTIAL IMPACTS OF CONTINUED CYLINDER STORAGE FOR THE ACTION ALTERNATIVES

For the action alternatives considered in the PEIS — long-term storage as UF_6, long-term storage as uranium oxide, use as uranium oxide, use as uranium metal, and disposal as uranium oxide — continued storage could be necessary for some portion of the DOE-generated cylinders at the K-25 site through approximately 2028. This 30-year storage period would correspond to the period during which construction of conversion, long-term storage, and/or disposal facilities would occur and during which the cylinders would be transported from the current locations to the processing locations. For analyses in the PEIS, the cylinder removal period was assumed to take place between 2009 and 2028; the number of cylinders would decrease by 5% annually during that time.

Potential environmental impacts associated with continued cylinder storage for the action alternatives were assessed with essentially the same methodology used to estimate impacts for the no action alternative (see Section 3.2 of this report and Appendix C of the PEIS). Through the year 2008, the number of maintenance activities (such as inspections, yard reconstruction, and painting) was assumed to be the same as for the no action alternative (Parks 1997). From 2009 through 2028, the number of maintenance activities was assumed to decrease by 5% annually, to correspond to the reduction in cylinder inventory that would be occurring. Impacts associated with maintenance activities (e.g., radiation doses to involved workers) would, therefore, generally be reduced for the action alternatives.

A key difference between the assessment of continued storage impacts conducted for the action alternatives and the assessment conducted for the no action alternative was in the assumptions made regarding potential numbers of breached cylinders. Because of impending cylinder movement or content transfer, cylinder yard improvement and cylinder painting might not occur at the same rate under the action alternatives as they would under the no action alternative. Because the painting schedule that would be followed under the action alternatives is not known, and to present reasonable upper bound estimates of impacts, no credit was taken for the effectiveness of cylinder yard improvements and painting in reducing cylinder corrosion rates. Therefore, the number of hypothetical cylinder breaches assumed for the action alternatives was estimated by assuming that painting and improved storage conditions were not effective in arresting continued corrosion of the cylinders (i.e., assuming that corrosion continued at historical rates) and by assuming that the population of cylinders at the site was decreasing at an annual rate of 5% between the years 2009 and 2028. These assumptions led to a higher number of assumed breaches for continued storage under the action alternatives than under the no action alternative, even though the number of years of storage would be lower. The assumptions for releases of uranium and HF from breached cylinders, as well as for methods to estimate water and soil impacts, were identical to those used for the assessment of impacts for the no action alternative. However, the outcome of the increased number of assumed cylinder breaches was a slightly higher estimate of impacts on groundwater, air quality, and human health and safety for the action alternatives, although the estimated impacts are still within applicable standards or guidelines (see Table 3.3). The impacts of continued cylinder storage under the action alternatives for the various technical areas of interest are discussed in Sections 3.4.1 through 3.4.11. Assessment methods are described in Appendix C of the PEIS.

3.4.1 Human Health — Normal Operations

3.4.1.1 Radiological Impacts

Estimated radiation doses and latent cancer risks are presented in Tables 3.23 and 3.24. Long-term radiological impacts (based on groundwater contamination) are provided in Table 3.25.

During continued cylinder storage, involved workers would receive an average dose of 260 mrem/yr from performing cylinder maintenance activities. The average annual collective dose for involved workers would be 3.0 person-rem/yr for approximately 12 workers. Radiation exposures of noninvolved workers and members of the general public would be less than 0.17 and 0.37 mrem/yr, respectively, from airborne emission of UO_2F_2. The dose for the general public MEI would be greater than that for the noninvolved worker MEI because of the close proximity from the assumed emissions point to the site boundary. Potential radiation exposure from the use of contaminated groundwater would result in a dose of less than 0.085 mrem/yr at the end of this period.

Long-term radiation exposure after the year 2028 from the use of contaminated groundwater would result in a maximum dose of 0.64 mrem/yr.

3.4.1.2 Chemical Impacts

Chemical impacts associated with continued cylinder storage could result primarily from exposure to uranium compounds and HF released from hypothetical cylinder breaches. Estimated impacts are given in Table 3.26. The highest hazard quotients result when the use of contaminated groundwater is considered in addition to exposures through inhalation, soil ingestion, and surface water ingestion (i.e., maximum hazard quotient of 0.08). Adverse health effects would not be expected from exposure to chemical contaminants associated with continued cylinder storage (that is, the estimated hazard indices would all be less than the threshold value of 1).

TABLE 3.23 Radiological Doses from Continued Cylinder Storage under Normal Operations at the K-25 Site for the Action Alternatives

Annual Dose to Receptor					
Involved Workers[a]		Noninvolved Workers[b]		General Public	
Average Individual Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose[c] (mrem/yr)	Collective Dose[d] (person-rem/yr)	MEI Dose[e] (mrem/yr)	Collective Dose[f] (person-rem/yr)
260	3.0	0.17	0.0031	0.37 (< 0.085)	0.017

[a] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual dose and collective dose for the worker population. The reported values are averages over the time period 1999–2028. Radiation doses to individual workers would be monitored by a dosimetry program and maintained below applicable standards, such as the DOE administrative control limit of 2,000 mrem/yr.

[b] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

[c] The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest dose. The reported values are the maximums over the time period considered.

[d] The reported collective doses are averages over the time periods considered. The size of the population of noninvolved workers was assumed to be about 3,500 for K-25.

[e] The MEI for the general public was assumed to be located off-site at a point that would yield the largest dose. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[f] Collective dose was estimated for the population within a radius of 50 miles (80 km) around the site. The reported values are averages over the time period considered. The off-site population is 877,000 for K-25. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

TABLE 3.24 Latent Cancer Risks from Continued Cylinder Storage under Normal Operations at the K-25 Site for the Action Alternatives

Annual Risk of Latent Cancer Fatality to Receptor					
Involved Worker[a]		Noninvolved Worker[b]		General Public	
Average Individual Risk (risk/yr)	Collective Risk (fatalities/yr)	MEI Risk[c] (risk/yr)	Collective Risk[d] (fatalities/yr)	MEI Risk[e] (risk/yr)	Collective Risk[f] (fatalities/yr)
1×10^{-4}	1×10^{-3}	7×10^{-8}	1×10^{-6}	2×10^{-7} ($< 8 \times 10^{-9}$)	9×10^{-6}

[a] Involved workers are those workers directly involved with the handling of materials. Impacts are presented as average individual risk and collective risk for the worker population. The reported values are averages over the time period 1999–2028.

[b] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. Exposures of noninvolved workers would result from airborne emissions of UO_2F_2 due to hypothetically breached cylinders. The exposure pathways considered included inhalation, external radiation, and incidental ingestion of soil.

[c] The MEI for the noninvolved workers was assumed to be at the on-site (outside storage yards) location that would yield the largest risk. The reported values are the maximums over the time period considered.

[d] The reported collective risks are averages over the time period considered. The size of the population of noninvolved workers was assumed to be about 3,500 for K-25.

[e] The MEI for the general public was assumed to be located off-site at a point that would yield the largest risk. The reported values are the maximums over the time period considered and are the results of exposures from inhalation, external radiation, and ingestion of plant foods, meat, milk, soil (all consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders and from drinking surface water (consequence of discharge of contaminated runoff water to a surface water body). Values within parentheses are the potential maximum doses from using contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[f] Collective risk was estimated for the population within a radius of 50 miles (80 km) around the three sites. The reported values are averages over the time period considered. The off-site population is 877,000 for K-25. Exposure pathways considered were inhalation, external radiation, and ingestion of plant foods, meat, milk, and soil (consequences of airborne emissions of UO_2F_2) due to hypothetically breached cylinders.

3.4.2 Human Health — Accident Conditions

The assessment of impacts conducted for potential accidents associated with continued cylinder storage under the action alternatives was similar to that for the no action alternative (Section 2.2.2) in that the same accidents were considered and the consequences of those accidents would be the same. However, because the duration of continued cylinder storage under the action alternatives is 11 years shorter than that assessed for the no action alternative (i.e., 30 years assumed for the action alternatives compared with 41 years assumed for the no action alternative), the risk of these accidents occurring would therefore be somewhat lower under the action alternatives.

TABLE 3.25 Long-Term Radiological Impacts to Human Health from Continued Cylinder Storage at the K-25 Site under the Action Alternatives[a,b]

Impact to MEI of General Public	
Radiation Dose[c] (mrem/yr)	Latent Cancer Risk[c] (risk/yr)
0.077 – 0.64	$4 \times 10^{-8} – 3 \times 10^{-7}$

[a] Long-term impacts correspond to the time after the year 2028.

[b] Long-term impacts would be caused by the potential use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock. Contamination of groundwater would result from releases from hypothetically breached cylinders and the resulting infiltration of UO_2F_2 to the deeper soils, eventually reaching the groundwater (UO_2F_2 is the product of UF_6 reacting with moisture in air).

[c] Radiation doses and latent cancer risks are expressed as ranges, which would result from different transport speeds of uranium in soil. The reported values are the maximum values that would occur after 2028, assuming no mitigation action was taken.

The activities considered in calculating the physical hazards associated with continued cylinder storage were routine cylinder inspections, ultrasonic inspections, valve monitoring and maintenance activities, cylinder relocations, cylinder yard construction or reconstruction, cylinder painting, and patching and content transfers of breached cylinders. The annual labor requirements and the corresponding fatality and injury risks to all workers for these activities were estimated to be less than 1 (0.02) for the fatality risk and about 23 injuries.

3.4.3 Air Quality

The assessment of air quality impacts from construction, relocating cylinders, and painting cylinders conducted for the no action alternative would also be applicable for the action alternatives because the assessment was based on maximum annual impacts (i.e., the same construction activities were assumed, as well as the same levels of relocating and painting cylinders during the initial years of continued storage). Potential impacts on air quality from these activities are discussed in Section 3.2.3.

The estimated HF emissions for the action alternatives would differ from those for the no action alternative because different numbers of breached cylinders were assumed. The numbers

TABLE 3.26 Chemical Impacts to Human Health from Continued Cylinder Storage under Normal Operations at the K-25 Site for the Action Alternatives

	Impacts to Receptor			
	Noninvolved Workers[a]		General Public[b]	
Time Period	Hazard Index[c] for MEI	Population Risk[d] (ind. at risk/yr)	Hazard Index[c] for MEI	Population Risk[d] (ind. at risk/yr)
1999–2028	1.1×10^{-3}	–	6.5×10^{-2} (1.1×10^{-2})	–
Long-term[e]	NA[f]	–	0.01 – 0.08	–

[a] Noninvolved workers are individuals who work on-site but not within the cylinder storage yards. The MEI for the noninvolved worker was assumed to be at the on-site (outside storage yards) location that would yield the largest exposure. Exposures would result from airborne emissions of UO_2F_2 and HF from hypothetically breached cylinders; the exposure pathways considered included inhalation and incidental ingestion of soil.

[b] The MEI for the general public was assumed to be located off-site at the point that would yield the largest exposure. Results reported are the maximum values for the time period considered and would result from exposure via inhalation; ingestion of soil (resulting from airborne emissions of UO_2F_2 and HF from hypothetically breached cylinders); and drinking surface water (consequence of the discharge of contaminated runoff water to a surface water body). Potential impacts during the storage period 1999–2028 (values within parentheses) were also evaluated from the use of contaminated groundwater for drinking, irrigating plant foods and fodder, and feeding livestock.

[c] The hazard index is an indicator for potential health effects other than cancer; a hazard index greater than 1 indicates a potential for adverse health effects and a need for further evaluation.

[d] Calculation of population risk is not applicable when the corresponding hazard index for the MEI is less than 1.

[e] Long-term impacts would result from using contaminated groundwater.

[f] NA = not applicable; workers were assumed not to ingest groundwater.

of hypothetical breaches and estimated resulting HF concentrations are given in Table 3.27. The estimated 2.7-: g/m^3 maximum 24-hour average HF concentration for the K-25 site is just below the Tennessee 24-hour average standard of 2.9 : g/m^3.

3.4.4 Water and Soil

3.4.4.1 Surface Water

The estimated number of cylinder breaches assumed to occur during continued cylinder storage for the action alternatives was used to calculate potential impacts to surface water quality. Each breached cylinder was assumed to release a maximum of 4 lb (1.8 kg) of uranium over 4 years; additional details on the methodology used to evaluate the impacts are given in Appendix C of the PEIS and Tomasko (1997b).

The estimated maximum uranium concentrations in runoff water leaving the yards would be about 130 : g/L (34 pCi/L). This concentration would occur in about the year 2018. After leaving the yards, the contaminated runoff was assumed to flow without loss to the nearest surface water, where it would mix and be diluted. For average flow conditions, the dilution would be large enough that the maximum concentration would be less than 0.1 : g/L (0.5 pCi/L) (see Table 3.28). This concentration is less than the EPA proposed drinking water MCL for uranium of 20 : g/L, used here for comparison. The contaminated water would then mix with water in the Clinch River, which would result in even greater dilution. Because of this mixing, impacts to the major rivers would not be measurable.

TABLE 3.27 Estimated Number of Breached Cylinders, Maximum HF Emissions, and Average Maximum HF Concentrations at the K-25 Site for the Action Alternatives

Maximum Number of Breaches Starting in a Single Year	Maximum Total Number of Active Breaches in a Single Year	Maximum HF Concentration (: g/m^3)	
		24-Hour Average	Annual Average
3	8	2.7	0.34

3.4.4.2 Groundwater

Methods for estimating groundwater impacts were the same as those used for the no action alternative (Section 3.2.4.2); however, a larger number of cylinder breaches was assumed to occur. Conservative estimates of the concentrations of uranium in groundwater were obtained by assuming the surface value to be equal to the maximum concentration in water leaving each yard during a time interval of approximately 20 years; this time interval corresponds to the time over which the concentration in surface water would be higher than half of its maximum value.

TABLE 3.28 Maximum Uranium Concentrations in Surface Waters for Continued Cylinder Storage at the K-25 Site under the Action Alternatives

Receiving Water	Dilution Factor	Maximum Concentration (: g/L)
Poplar Creek	2,550	0.05
Clinch River	94	0.0005

At the end of the time period considered for the action alternatives (1999–2028), the concentration of uranium in groundwater directly below the edge of the surface contamination at the K-25 site is estimated to be about 1.3 : g/L (0.3 pCi/L), for a retardation factor of 5 (Table 3.29) (Tomasko 1997b). This concentration is less than the proposed EPA drinking water MCL for uranium of 20 : g/L, used here for comparison (EPA 1996).

A maximum concentration of about 9 : g/L (3 pCi/L) would occur between the years 2070 and 2080, assuming a retardation factor of 5. The maximum concentration would be less than the EPA proposed drinking water guideline. For a retardation factor of 50 (relatively immobile uranium transport), maximum concentrations would be about 10 times less. This concentration would occur between the years 2500 and 2700.

Assuming a retardation factor of 5 and a distance of 1,000 ft (300 m) from the edge of the source area, the maximum concentration of uranium would be about 9 : g/L (3 pCi/L). For less mobile conditions (retardation of 50), the maximum concentration would be about 10 times less.

3.4.4.3 Soil

The maximum uranium concentration in soil for a distribution coefficient of 50 (relatively high sorption capacity) would be about 6.5 : g/g. If the soil had a lower sorption capacity (distribution coefficient of 5), the soil concentration would be 10 times lower. This maximum soil concentration associated with continued cylinder storage under the action alternative is much lower than the recommended EPA guideline levels of 230 : g/g for residential soil or 1,000 : g/g for industrial soil (EPA 1995).

TABLE 3.29 Groundwater Concentrations for Continued Cylinder Storage for Two Soil Characteristics at the K-25 Site under the Action Alternatives[a]

	X = 0			X = 1,000 ft		
	Concentration		Time to Maximum Concentration	Concentration		Time to Maximum Concentration
Parameter	pCi/L	:g/L		pCi/L	:g/L	
Retardation Factor = 5						
Concentration at 30 years	0.33	1.3				
Maximum concentration	2.5	9.4	> 70 years	2.0	7.7	> 70 years
Retardation Factor = 50						
Maximum concentration	0.3	1.1	> 500 years	0.2	0.8	> 500 years

[a] Retardation factors describe how readily a contaminant such as uranium moves through the soil in groundwater. A retardation factor of 5 represents a case in which the uranium moves relatively rapidly in the soil; a retardation factor of 50 represents a case in which uranium moves slowly.

3.4.5 Socioeconomics

The methods used to assess socioeconomic impacts of continued cylinder storage for the action alternatives were the same as those used for the no action alternative (Section 3.2.5). Impacts are presented in Table 3.30. Construction impacts would be identical to those estimated for the no action alternative because all construction would take place during the time period 1999–2008, when identical activities are assumed. The estimated impacts from operations under the action alternatives are slightly higher than those estimated for the no action alternative, primarily because of the increased number of cylinder breaches assumed, which would require increased levels of activities for repairs, thus leading to increased employment. Under the action alternatives, continued storage activities would still have a negligible impact on socioeconomic conditions in the ROI surrounding the site.

3.4.6 Ecology

For continued cylinder storage under the action alternatives, the maximum annual average HF concentration would be 0.081 :g/m^3 for the K-25 site (Section 3.4.3). Resulting impacts to biota would be expected to be negligible. Contamination of soils near the storage yards by surface runoff could result in a maximum uranium concentration of 6.5 :g/g at the site (Section 3.4.4.3). The predicted concentration for the K-25 site is approximately the same as the lowest uranium concentration known to produce toxic effects in plants (5 :g/g). The extent of vegetation affected would be restricted to the area of surface runoff from the yards. Therefore, impacts to vegetation

TABLE 3.30 Potential Socioeconomic Impacts of Continued Cylinder Storage at the K-25 Site under the Action Alternatives

Parameter	Impacts from Construction[a]	Impacts from Operations[b]
Economic activity in the ROI		
Direct jobs	10	40
Indirect jobs	50	70
Total jobs	60	110
Income ($ million)		
Direct income	0.4	3.8
Total income	1.5	5.1
Population in-migration into the ROI	20	30
Housing demand		
Number of units in the ROI	10	10
Public finances		
Change in ROI fiscal balance (%)	0.0	0.0

[a] Impacts for peak construction year. Construction activities were assumed to occur over 1 year (1999) at the K-25 site.

[b] Impacts for peak year of operations. Duration of operations was assumed to be 30 years (1999–2028).

would be expected to be negligible to low. Surface runoff from the storage yards would have a maximum uranium concentration of 130 :g/L (34 pCi/L) at the site (Section 3.4.4.1). Resulting impacts to maximally exposed organisms in the nearest receiving surface water body at the site would be expected to be negligible. Uranium concentrations in groundwater would be considerably less and resulting impacts to aquatic biota would be negligible.

Uranium concentrations in groundwater following the cylinder removal period would be very low, and long-term impacts to aquatic biota would not be expected. Contaminants associated with cylinder storage would not occur in other environmental media following the cylinder removal period.

3.4.7 Waste Management

As for the no action alternative, the principal wastes that are expected to be generated during continued cylinder storage are uranium-contaminated scrap metal from breached cylinders and failed valves, assumed to be LLW, and solid process residue from cylinder painting, assumed to be LLMW. The total amounts of these waste types estimated to be generated for continued cylinder storage under the action alternatives is given in Table 3.31. The annual amount of LLW generated would be less than 2% of site LLW generation for the site. The maximum annual amount of LLW generated during continued cylinder storage would represent less than 1% of the annual DOE LLW generation.

TABLE 3.31 Waste Generated at the K-25 Site during Continued Cylinder Storage under the Action Alternatives (1999–2028)

Waste (m^3)	
LLW[a]	LLMW[b]
206	45

[a] Contaminated scrap metal from breached cylinders that will require emptying.

[b] Inorganic process residues from cylinder painting.

For the K-25 site, the annual amount of LLMW generation would be less than 1% of site LLMW generation. The input of LLMW from continued storage would represent less than 1% of the total nationwide LLMW load.

Overall, the waste input resulting from the continued storage of cylinders under the action alternatives would have negligible impacts on waste management capabilities at the K-25 site. Impacts on national waste management capabilities would be negligible.

3.4.8 Resource Requirements

Resource requirements for continued cylinder storage under the action alternatives are summarized in Table 3.32. The resource requirements for construction would be identical to those for the no action alternative. The upper end of the range of annual requirements shown in Table 3.32 generally corresponds to the upper end of the range estimated for the no action alternative; these requirements represent the early years of continued cylinder storage when some construction activities are planned. The lower end of the range of annual resource requirements is lower than the lower values for the no action alternative because maintenance of the decreasing cylinder inventory would require fewer resources.

The total quantities of commonly used construction materials needed for continued storage under the action alternatives are expected to be small compared with local sources. No strategic and critical materials are projected to be consumed for either construction or operations. Small amounts of diesel fuel and gasoline are projected to be used. The required material resources during operations would appear to be readily available.

TABLE 3.32 Resource Requirements of Construction and Operations for Continued Cylinder Storage at the K-25 Site under the Action Alternatives

Materials/Resource	Consumption during 1999–2028
Construction	
Solids	
Concrete (yd^3)	8,000
Construction aggregate (yd^3)	12,000
Special coatings (yd^2)	36,000
Liquids (gal)	
Gasoline	1,300
Diesel fuel	7,300
Operations[a]	
Solids	
55-gal drums (each)	10 – 18
Cylinder valves (1-in.) (each)	1 – 2
Liquids (gal/yr)	
Gasoline	450 – 1,000
Diesel fuel	800 – 2,600
Zinc-based paint	470 – 1,000

[a] Values reported as ranges generally correspond to varying resource requirements during years for which activities are planned.

3.4.9 Land Use

Construction activities assumed for continued storage under the action alternatives are identical to those assumed for the no action alternative. Therefore, potential land-use impacts would be the same as those discussed in Section 3.2.9.

3.4.10 Cultural Resources

Potential impacts to cultural resources under the action alternatives would be identical to those discussed in Section 3.2.10.

3.4.11 Environmental Justice

Because no screening criteria limits for radiological and chemical sources under normal operations were exceeded under the action alternatives, no disproportionate impacts to minority and low-income populations would be associated with normal operations for continued cylinder storage. The assessment of impacts for potential accidents associated with continued cylinder storage under the action alternatives is similar to that for the no action alternative (Section 3.2.11) in that the same accidents were considered and the consequences of those accidents would be the same. However, because the duration of continued cylinder storage under the action alternatives is 11 years shorter than that assessed for the no action alternative (i.e., 30 years assumed for the action alternatives compared with 41 years assumed for the no action alternative), the risk of these accidents occurring is somewhat lower. However, the conclusion that no disproportionate impacts would be associated with continued cylinder storage under the no action alternative is still applicable for the action alternatives because risks are lower for these alternatives.

4 ENVIRONMENTAL IMPACTS OF OPTIONS FOR PREPARING CYLINDERS FOR SHIPMENT OR LONG-TERM STORAGE

The term "cylinder preparation" refers to the activities necessary to prepare depleted UF_6 cylinders for off-site transportation. For this report, transportation of depleted UF_6 cylinders was assumed to be required from the site to either a conversion facility or a long-term storage site (for long-term storage of UF_6). UF_6 cylinders have been transported safely by truck and rail between DOE facilities, electric utilities, reactor fuel fabricators, and research nuclear reactors for about 40 years.

Depleted UF_6 cylinders were designed, built, tested, and certified to meet U.S. Department of Transportation (DOT) requirements for shipment by truck and rail. The DOT requirements, specified in Title 49 of the CFR, are intended to maintain the safety of shipments during both routine and accident conditions. Cylinders meeting the DOT requirements could be loaded directly onto specially designed truck trailers or railcars for shipment. However, after several decades in storage, some cylinders no longer meet the DOT requirements. Two cylinder preparation options, which address different approaches that could be used to transport the depleted UF_6 stored in these cylinders, are considered in this report. These two options, discussed in detail in Section 4.2, are a cylinder overcontainer option and a cylinder transfer option.

Cylinder Preparation Options

Cylinder preparation refers to the activities necessary to prepare depleted UF_6 cylinders for off-site transportation. Depleted UF_6 cylinders were designed, built, tested, and certified to meet U.S. Department of Transportation (DOT) requirements for shipment by truck and rail. However, after several decades in storage, some cylinders no longer meet these requirements. Two options for preparing these cylinders for shipment are considered in the PEIS.

Cylinder Overcontainers. Cylinders that do not meet DOT requirements could be placed inside protective metal "overcontainers" for shipment. These reusable overcontainers, which would be slightly larger than a cylinder, would be designed to meet all DOT requirements.

Cylinder Transfer. In this option, the depleted UF_6 in cylinders that do not meet DOT requirements would be transferred to new cylinders capable of being transported.

Note: For both options, cylinders that meet DOT shipment requirements would be shipped directly.

It is unknown exactly how many of the depleted UF_6 cylinders currently do not meet the DOT transportation requirements. The potential problems with cylinders are related to three DOT requirements that must be satisfied before shipment: (1) cylinders must be filled to less than 62% of the maximum capacity (the fill-limit was reduced to 62% from 64% around 1987); (2) the pressure within cylinders must be less than atmospheric pressure; and (3) cylinders must be free of damage or defects, such as dents, and have a specified minimum wall thickness. Cylinders not meeting these requirements are referred to as overfilled, overpressurized, and substandard, respectively. Some cylinders may fail to meet more than one requirement.

The assessment of cylinder preparation options considers the environmental impacts of preparing the entire depleted UF_6 cylinder inventory at the K-25 site for shipment over a 20-year period. Prior to shipment, each cylinder would be inspected to determine if it meets DOT requirements. This inspection would include a record review to determine if the cylinder is overfilled; a visual inspection for damage or defects; a pressure check to determine if the cylinder is overpressurized; and an ultrasonic wall thickness measurement (if necessary based on the visual inspection). If a cylinder passed the inspection, the appropriate documentation would be prepared, and the cylinder would be loaded directly for shipment. If a cylinder failed the inspection, it would be prepared by using one of the two cylinder preparation options (see Section 4.2).

The estimated number of cylinders not meeting DOT requirements at the K-25 site would range from 2,342 to 4,683 (the entire K-25 inventory). On the basis of this estimate, there would be a need to provide overcontainer or cylinder transfer capacities for about 120 to 234 cylinders annually and to prepare from 0 to 120 standard cylinders per year for shipment.

The environmental impacts from the cylinder preparation options were evaluated on the basis of information provided in the engineering analysis report (Lawrence Livermore National Laboratory [LLNL] 1997), i.e., preconceptual design data for each option, including descriptions of facility layouts; resource requirements; estimated effluents, wastes, and emissions; and potential accident scenarios. In the engineering analysis report, estimates for cylinder transfer operations ranged in capacity from 320 to 1,600 cylinders processed per year; whereas overcontainer and standard cylinder operations were addressed on a site-specific basis for a reference case for each site (i.e., 234 cylinders/yr with overcontainers for the K-25 site), with some information provided on scaling up or down from the reference case (LLNL 1997). Supporting data for the overcontainer and transfer facility analyses were derived by Folga (1996b) by using information provided in the engineering analysis report (LLNL 1997).

For assessment purposes, it was assumed that all cylinders would require transportation. However, the actual need for transportation of cylinders would depend on site selection and other considerations to be addressed in the second tier of the NEPA process.

4.1 SUMMARY OF CYLINDER PREPARATION OPTION IMPACTS

This section provides a summary of the potential environmental impacts associated with the cylinder preparation options at the K-25 site. Additional discussion and details related to the assessment methodologies and results for individual areas of impact are provided in Section 4.3.

Potential environmental impacts for the K-25 site are summarized in Table 4.1. Ranges of impacts are presented for the overcontainer option, the cylinder transfer option, and the preparation

TABLE 4.1 Summary of Cylinder Preparation Impacts for the K-25 Site

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 42 – 85 person-rem Total number of LCFs: 0.02 – 0.03 LCF	**Involved Workers:** Total collective dose: 410 – 480 person-rem Total number of LCFs: 0.2 LCF	**Involved Workers:** Total collective dose: 0 – 27 person-rem Total number of LCFs: 0 – 0.01 LCF
Noninvolved Workers: No impacts	**Noninvolved Workers:** Annual dose to MEI : $2.0 \times 10^{-6} – 3.7 \times 10^{-6}$ rem/yr Annual cancer risk to MEI: $8 \times 10^{-13} – 2 \times 10^{-12}$ per year Total collective dose: $3.1 \times 10^{-5} – 5.6 \times 10^{-5}$ person-rem Total number of LCFs: $1 \times 10^{-8} – 2 \times 10^{-8}$ LCF	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** Annual dose to MEI: $2.4 \times 10^{-5} – 2.9 \times 10^{-5}$ mrem/yr Annual cancer risk to MEI: 1×10^{-11} per year Total collective dose to population within 50 miles: $9.8 \times 10^{-4} – 1.8 \times 10^{-3}$ person-rem Total number of LCFs in population within 50 miles: $5 \times 10^{-7} – 9 \times 10^{-7}$ LCF	**General Public:** No impacts
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts

TABLE 4.1 (Cont.)

Impacts from Preparation of Problem Cylinders[a]: Cylinder Overcontainer Operations	Impacts from Preparation of Problem Cylinders[a]: Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
Human Health – Accidents: Radiological		
Bounding accident: Vehicle-induced fire, 3 full 486 cylinders[c]	**Bounding accident:** Vehicle-induced fire, 3 full 486 cylinders[c]	**Bounding accident:** Vehicle-induced fire, 3 full 486 cylinders[c]
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	**Bounding accident frequency:** 1 in 10,000 years to 1 in 1 million years	**Bounding accident frequency:** 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Dose to MEI: 0.02 rem	Dose to MEI: 0.02 rem	Dose to MEI: 0.02 rem
Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}
Collective dose: 16 person-rem	Collective dose: 16 person-rem	Collective dose: 16 person-rem
Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Dose to MEI: 0.013 rem	Dose to MEI: 0.013 rem	Dose to MEI: 0.013 rem
Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}
Collective dose to population within 50 miles: 63 person-rem	Collective dose to population within 50 miles: 63 person-rem	Collective dose to population within 50 miles: 63 person-rem
Number of LCFs in population within 50 miles: 0.03 LCF	Number of LCFs in population within 50 miles: 0.03 LCF	Number of LCFs in population within 50 miles: 0.03 LCF
Human Health – Accidents: Chemical		
Bounding accident: Vehicle-induced fire, 3 full 48G cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)[c]	**Bounding accident:** Vehicle-induced fire, 3 full 48G cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)[c]	**Bounding accident:** Vehicle-induced fire, 3 full 48G cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)[c]
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years (vehicle-induced fire); 1 in 100 to 1 in 10,000 (cylinder spill)	**Bounding accident frequency:** 1 in 10,000 years to 1 in 1 million years (vehicle-induced fire); 1 in 100 to 1 in 10,000 (cylinder spill)	**Bounding accident frequency:** 1 in 10,000 years to 1 in 1 million years (vehicle-induced fire); 1 in 100 to 1 in 10,000 (cylinder spill)
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 770 persons	Number of persons with potential for adverse effects: 770 persons	Number of persons with potential for adverse effects: 770 persons
Number of persons with potential for irreversible adverse effects 140 persons	Number of persons with potential for irreversible adverse effects: 140 persons	Number of persons with potential for irreversible adverse effects 140 persons

TABLE 4.1 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
	Human Health – Accidents: Chemical (Cont.)	
General Public: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 550 persons Number of persons with potential for irreversible adverse effects: 0 persons	**General Public:** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 550 persons Number of persons with potential for irreversible adverse effects: 0 persons	**General Public:** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 550 persons Number of persons with potential for irreversible adverse effects: 0 persons
	Human Health — Accidents: Physical Hazards	
Operations: **All Workers:** Less than 1 (0.007 – 0.014) worker fatality, approximately 9 – 18 worker injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.17 – 0.21) worker fatality, approximately 94 – 140 worker injuries	**Operations:** **All Workers:** Less than 1 (0 – 0.006) worker fatality, approximately 0 ! 7 worker injuries
	Air Quality	
Construction: Not applicable	**Construction:** 24-hour PM_{10} impacts potentially as large as 87% of standard; concentrations of other criteria pollutants all below 11% of respective standards	**Construction:** Not applicable
Operations: Concentrations of all criteria pollutants below 0.01% of respective standards.	**Operations:** Concentrations of all criteria pollutants below 0.07% of respective standards	**Operations:** Concentrations of all criteria pollutants below 0.004% of respective standards
	Water	
Construction: Not applicable	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Not applicable
Operations: None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards

TABLE 4.1 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
	Soil	
Construction: Not applicable	**Construction:** Negligible, but temporary, impacts	**Construction:** Not applicable
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts
	Socioeconomics[d]	
Jobs: <5 peak year, preoperations; 80 per year over 20 years, operations	**Jobs** 130 peak year, construction; 130 per year over 20 years, operations	**Jobs:** <5 peak year, preoperations; 40 per year over 20 years, operations
Income: \$0.1 million peak year, preoperations; \$5 million per year over 20 years, operations	**Income:** \$6 million peak year, construction; \$7 million per year over 20 years, operations	**Income:** \$0.1 million peak year, preoperations; \$2 million per year over 20 years, operations
Preoperations and Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Construction and Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances	**Preoperations and Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances
	Ecology	
Construction: Not applicable	**Construction:** Potentially moderate impacts to vegetation, wildlife, and wetlands	**Construction:** Not applicable
Operations: Negligible impacts	**Operations:** Negligible impacts	**Operations:** No impacts
	Waste Management	
No impacts on regional or national waste management operations	No impacts on regional or national waste management operations	No impacts on regional or national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale
	Land Use	
No impacts	Use of approximately 12 acres; negligible impacts	No impacts

TABLE 4.1 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
	Cultural Resources	
Construction: No impacts	**Construction:** Cannot be determined	**Construction:** No impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts

[a] Problem cylinders are cylinders not meeting DOT transportation requirements, either because they are (1) overfilled, (2) over-pressurized, or (3) damaged or substandard with respect to wall thickness. LCF = latent cancer fatality; MEI = maximally exposed individual; PM_{10} = particulate matter with a mean diameter of 10 :m or less; ROI = region of influence.

[b] These impacts must be added to those for either of the two options for preparation of problem cylinders.

[c] The bounding radiological accident was defined as the accident that would result in the highest dose and risk to the general public MEI; the bounding chemical accident was defined as the accident that would result in the highest population risk (number of people affected).

[d] For construction, direct jobs and direct income are reported for the peak construction year. For operations, direct jobs and income are presented as annual averages. See Section 4.3.5 for details on indirect impacts in the K-25 site ROI.

of standard cylinders (which is required for either option). On the basis of information in Table 4.1 and Section 4.3, the following general conclusions may be drawn:

- For the cylinder overcontainer option and preparation of standard cylinders, impacts during normal operations would be small and limited to involved workers. No impacts to the off-site public or the environment would occur because no releases would be expected and no construction activities would be required.

- For the cylinder transfer option, impacts during construction and normal operations would generally be small and limited primarily to involved workers. Some small off-site releases of hazardous and nonhazardous materials would occur, although these would have negligible impacts on the off-site public and environment. Construction activities could temporarily impact air quality, but concentrations of criteria pollutants would all be within standards.

- For all cylinder preparation options, there is a potential for low-probability accidents (UF_6 cylinders engulfed in a fire) that could have large consequences. The accident impacts would be limited primarily to workers, but off-site impacts are possible.

4.2 DESCRIPTION OF OPTIONS

This section provides a brief summary of the cylinder preparation options considered in the assessment of impacts. The information is based on preconceptual design data provided in the engineering analysis report (LLNL 1997). The engineering analysis report includes much more detailed information, including descriptions of facility layouts, resource requirements, estimates of effluents, wastes, and emissions, and descriptions of potential accident scenarios.

Prior to shipment, each cylinder would be inspected to determine if it meets DOT requirements. This inspection would include a record review to determine if the cylinder is overfilled; a visual inspection for damage or defects; a pressure check to determine if the cylinder is overpressurized; and an ultrasonic wall thickness measurement (if necessary based on the visual inspection). If a cylinder passed the inspection, the appropriate documentation would be prepared, and the cylinder would be loaded directly for shipment.

The preparation of standard cylinders for shipment (cylinders that meet DOT requirements) would include inspection activities, unstacking, on-site transfer, and loading onto a truck trailer or railcar. The cylinders would be secured using the appropriate tiedowns, and the shipment would be labeled in accordance with DOT requirements. Handling and support equipment and procedures for on-site movement and loading the cylinders would be of the same type currently used for cylinder management activities at the three storage sites.

4.2.1 Cylinder Overcontainers

Cylinder overcontainers are one option for transporting cylinders that do not meet DOT requirements. An overcontainer is simply a container into which a cylinder would be placed for shipment. The metal overcontainer would be designed, tested, and certified to meet all DOT shipping requirements. The overcontainer would be suitable to contain, transport, and store the cylinder contents regardless of cylinder condition. In addition, the overcontainers could be designed as pressure vessels, enabling the withdrawal of the depleted UF_6 from the cylinder in an autoclave (a device used to heat cylinders using hot air).

The type of overcontainer evaluated in the PEIS, shown in Figure 4.1, is a horizontal “clamshell” vessel (LLNL 1997). For transportation, a cylinder not meeting DOT requirements would be placed into an overcontainer already on a truck trailer or railcar. The overcontainer would be closed, secured, and the shipment would be labeled in accordance with DOT requirements. The handling and support equipment for on-site movement and loading the cylinder into the overcontainer would be of the same type currently used for cylinder management activities at the three DOE sites. The overcontainers could be reused following shipment. The overcontainer option would not require the construction of new facilities.

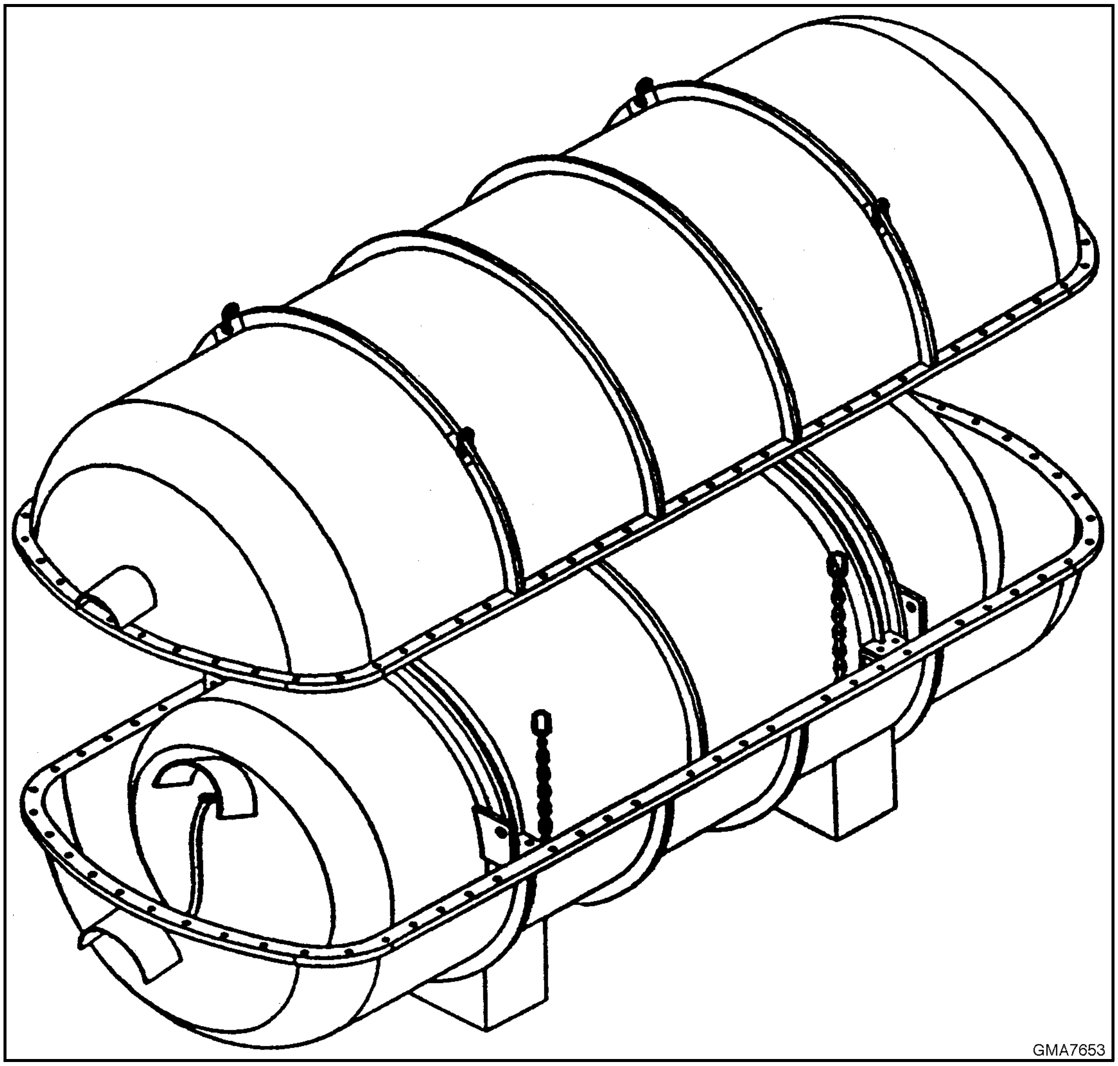

FIGURE 4.1 Horizontal "Clamshell" Overcontainer for Transportation of Cylinders Not Meeting DOT Requirements (Source: LLNL 1997)

4.2.2 Cylinder Transfer

A second option for transporting cylinders that do not meet DOT requirements would be to transfer the depleted UF_6 from substandard cylinders to new cylinders that meet all DOT requirements. This option would require the construction of a new facility. A representative transfer facility is shown in Figure 4.2. The transfer facility would be a stand-alone facility capable of receiving cylinders, storing a small number of cylinders, and transferring the contents to new cylinders. The transfer of depleted UF_6 would take place in a process building by placing substandard cylinders into autoclaves. The autoclaves would be used to heat the contents of the cylinder (using hot air), forming UF_6 gas which then would be piped to a new cylinder. The new cylinders could be shipped by placing them directly on appropriate trucks or railcars. The empty cylinders would be

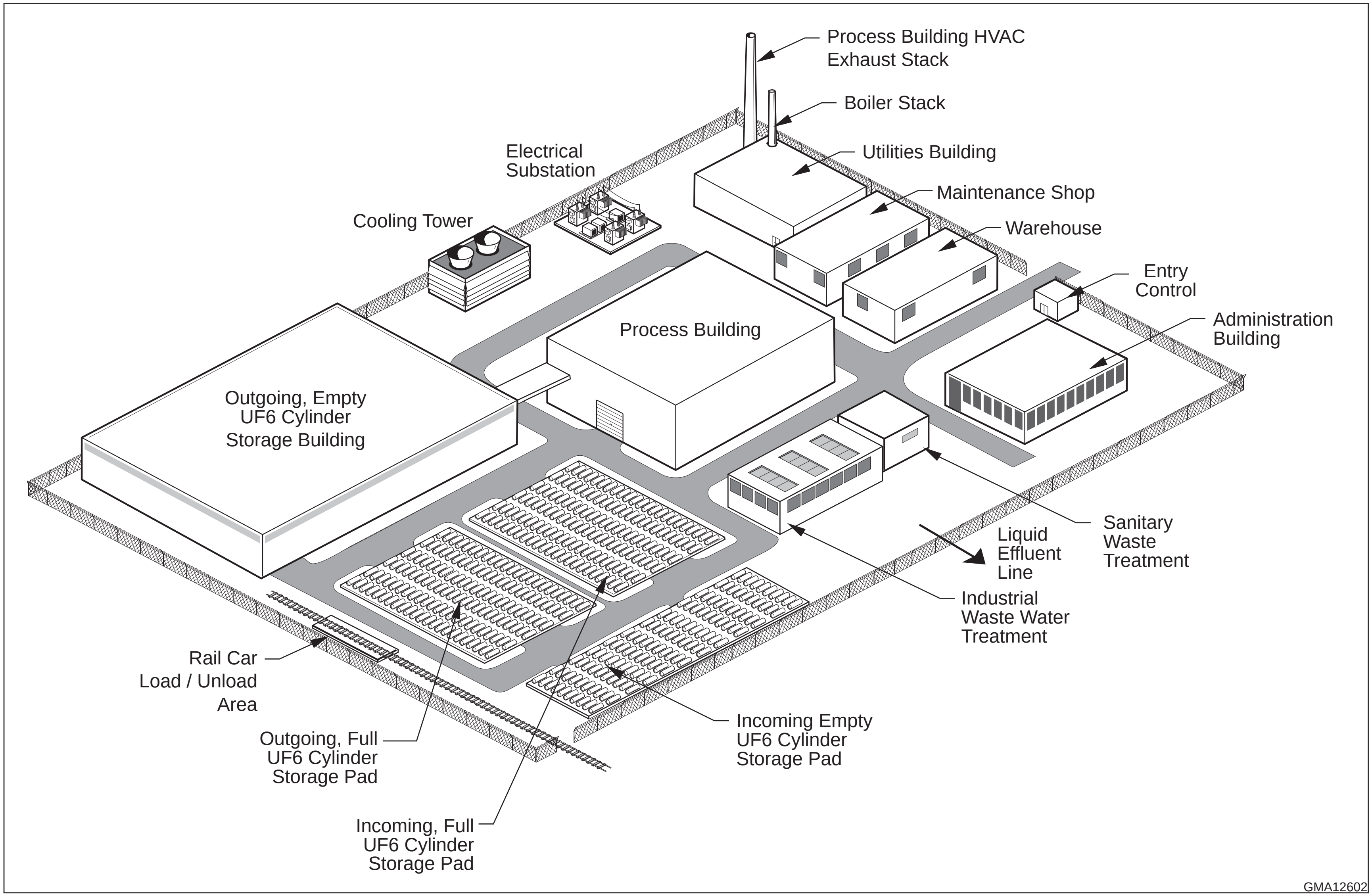

FIGURE 4.2 Representative Layout of a Transfer Facility Site (Source: LLNL 1997)

cleaned and treated with other scrap metals. (See Appendix F of the PEIS for details on the treatment of empty cylinders.)

4.3 IMPACTS OF OPTIONS

This section provides a summary of the potential environmental impacts associated with the cylinder preparation options, including impacts from construction (of a cylinder transfer facility), and during operations. Information related to the assessment methodologies for each area of impact is provided in Appendix C of the PEIS.

The environmental impacts from the cylinder preparation options were evaluated on the basis of the information described in the engineering analysis report (LLNL 1997) and in Folga (1996a). The following general assumptions apply to the assessment of impacts:

- The assessment considers preparation of cylinders that meet DOT requirements (standard cylinders), as well as those cylinders that do not meet the requirements.

- Evaluation of standard cylinder preparation and the cylinder overcontainer option includes only an operational phase — no construction activities would be required. Additionally, these options would not generate emissions of uranium compounds or HF during normal operations.

- The evaluation of the cylinder transfer option includes construction of a facility in addition to operations. The operation of a cylinder transfer facility would involve small releases of uranium compounds and HF as air and water effluents during normal operations.

- Impacts were evaluated by assuming a range in annual processing requirements because the actual number of cylinders that would not meet DOT requirements at the time of shipment could not be determined. The ranges of problem cylinders are discussed in the opening of this chapter. The remaining cylinders were assumed to be standard cylinders that could be shipped directly.

- Cylinder preparation activities would take place over a 20-year period, from 2009 through 2028, for all alternatives except the no action alternative, which does not involve cylinder preparation.

4.3.1 Human Health — Normal Operations

4.3.1.1 Radiological Impacts

Potential radiological impacts for the cylinder preparation options were assessed for involved workers, noninvolved workers, and the general public. Detailed discussions of the methodologies used in the radiological impact analyses are provided in Appendix C of the PEIS and Cheng et al. (1997).

Impacts to involved workers would result primarily from external radiation and would depend only on the number of cylinders handled. The estimated collective doses to involved workers are presented in Figures 4.3, 4.4, and 4.5 for the overcontainer option, cylinder transfer option, and preparation of standard cylinders, respectively. Because no airborne or waterborne releases of uranium would be generated for the overcontainer option and preparation of standard cylinders, no radiological impacts would be expected to noninvolved workers or members of the general public. Impacts to these two receptors for the cylinder transfer option are presented in Figures 4.6 through 4.9. The ranges of impacts are due to assumed numbers of cylinders handled annually.

In general, impacts for the overcontainer option would be less than those for the cylinder transfer option. The average doses to involved workers for all cylinder preparation activities would be less than 660 mrem/yr, which is less than the regulatory limit of 5,000 mrem/yr (10 CFR Part 835). Exposure of noninvolved workers and members of the general public would be extremely small, less than 3.0×10^{-5} mrem/yr.

4.3.1.1.1 Overcontainer Option

Potential external radiation exposures of involved workers would occur from preshipment inspection, testing, and surveying of cylinders; unstacking and retrieving cylinders; on-site transportation of cylinders by straddle buggy; loading cylinders into overcontainers placed on trucks or railcars; and packaging cylinders. The annual collective dose to involved workers was estimated to be approximately 2.1 to 4.3 person-rem/yr for about 4 to 8 workers at the K-25 site. Assuming that the workers would work 5 hours per day with an availability factor of 75%, i.e., 3.75 hours per day for cylinder preparation activities (Folga 1996c), the average individual involved worker dose would be approximately 540 mrem/yr. The corresponding average cancer risk would be approximately 0.0002 per year (i.e., an individual's chance of developing a latent fatal cancer would be less than 1 in 5,000 per year).

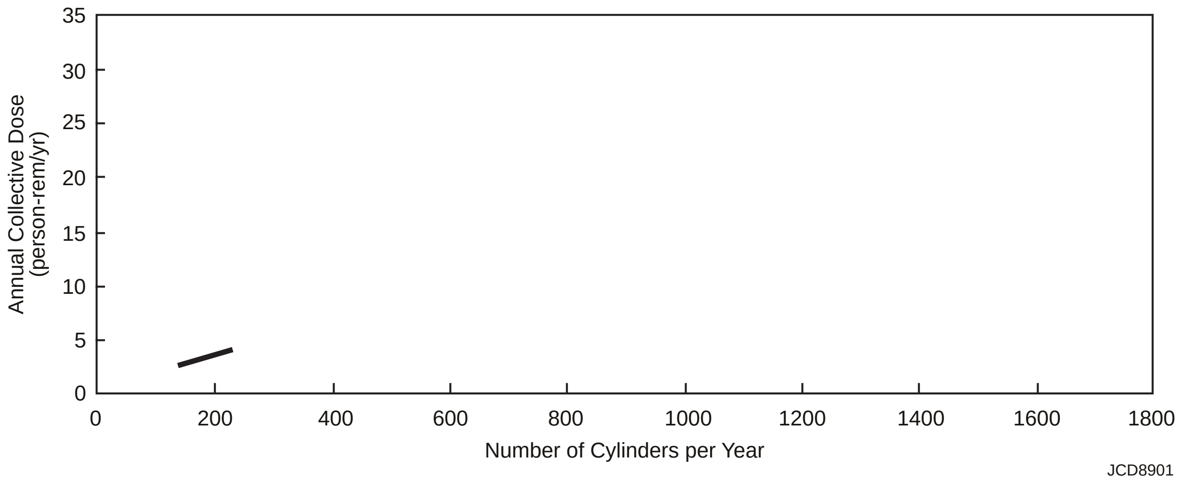

FIGURE 4.3 Annual Collective Dose to Involved Workers at the K-25 Site from Preparing Problem Cylinders for Shipment Using Overcontainers

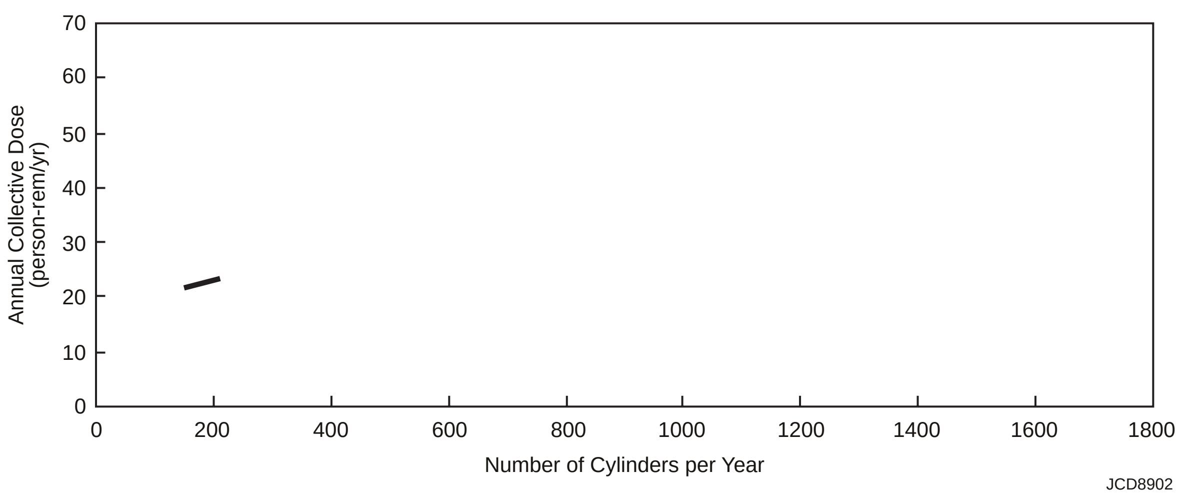

FIGURE 4.4 Estimated Annual Collective Dose to Involved Workers at the K-25 Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology

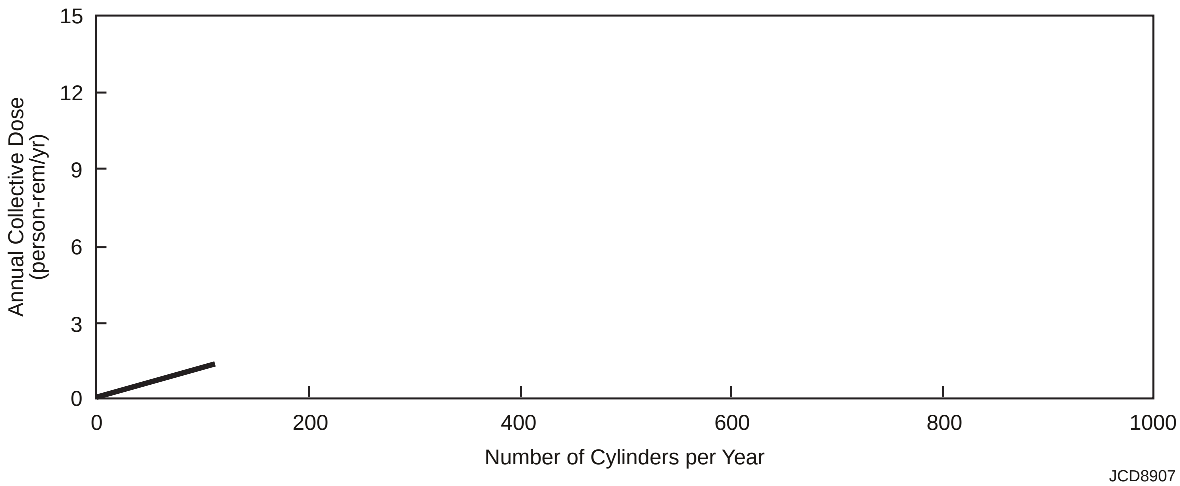

FIGURE 4.5 Annual Collective Dose to Involved Workers at the K-25 Site from Preparing Standard Cylinders for Shipment

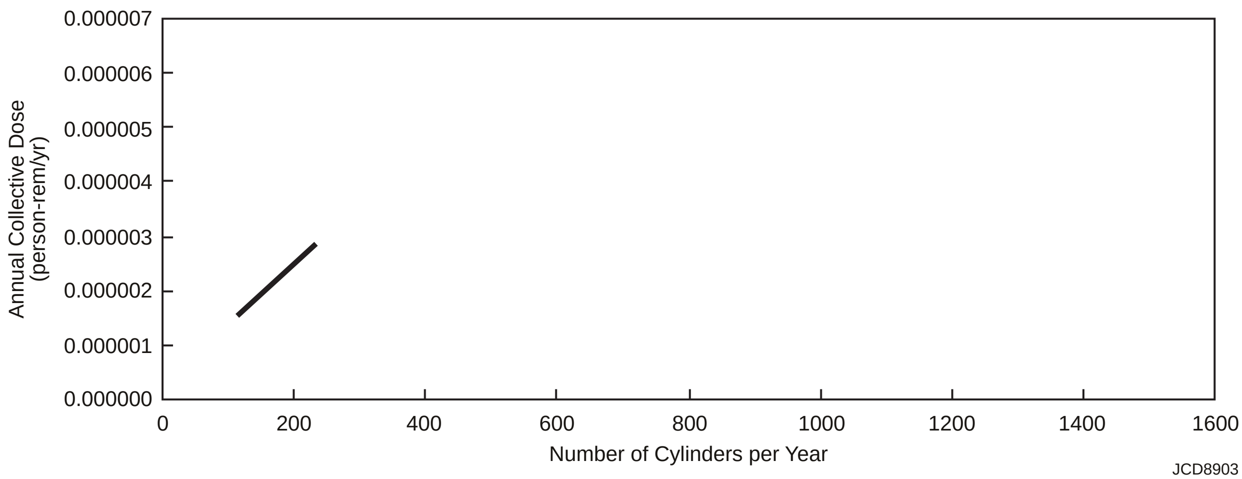

FIGURE 4.6 Estimated Annual Collective Dose to Noninvolved Workers at the K-25 Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (population size of noninvolved workers: about 3,500 at the K-25 Site)

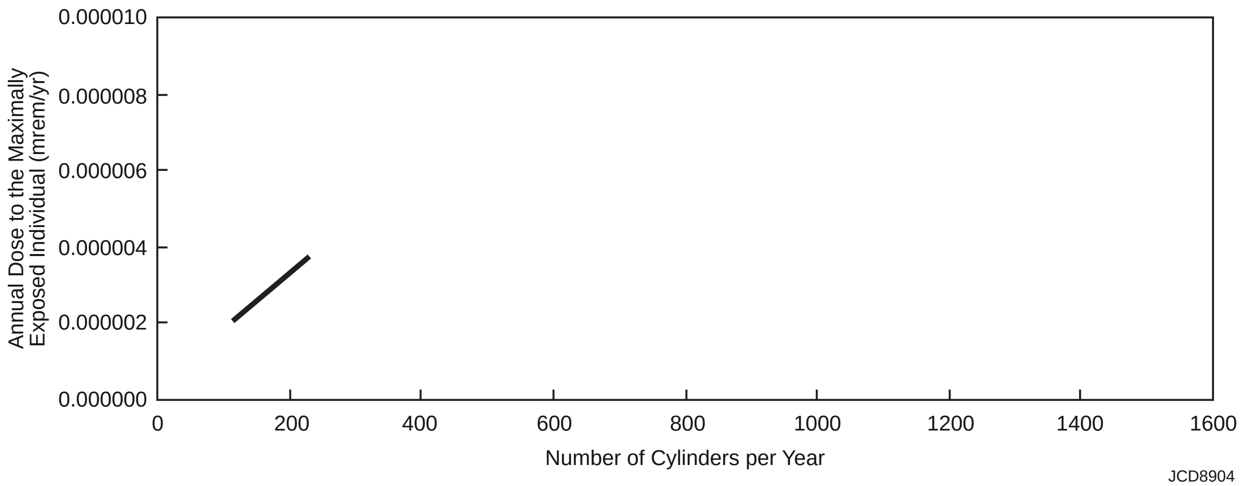

FIGURE 4.7 Estimated Annual Dose to the Noninvolved Worker MEI at the K-25 Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology

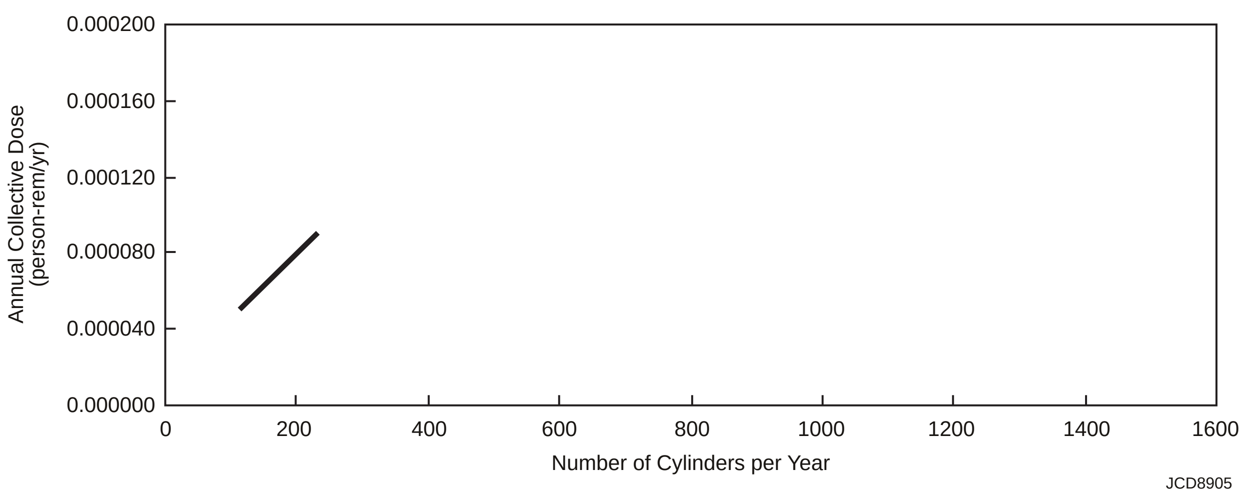

FIGURE 4.8 Estimated Annual Collective Doses to the General Public at the K-25 Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (exposure to airborne emissions; population size of general public: about 877,000)

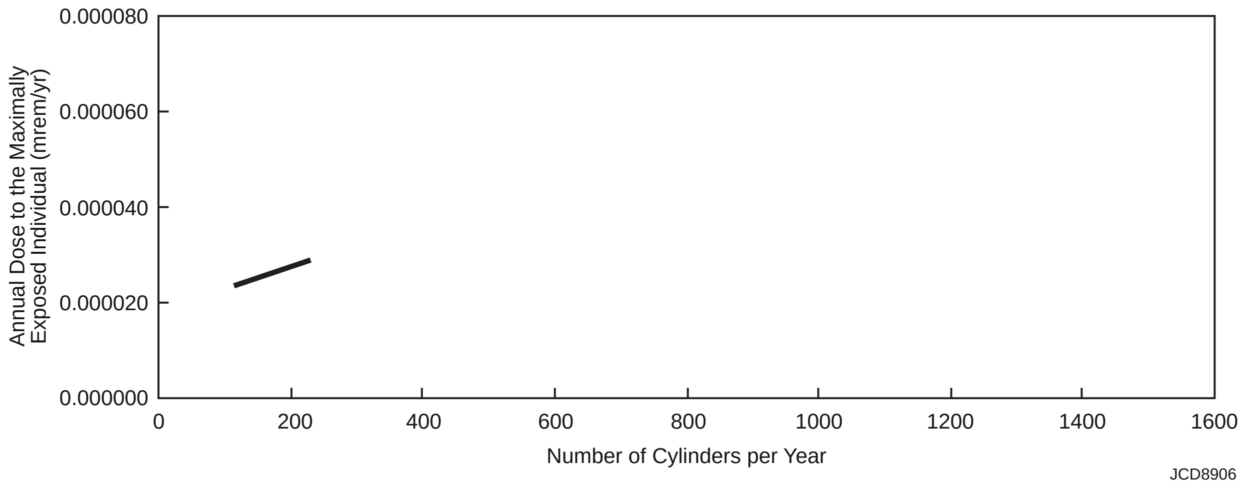

FIGURE 4.9 Estimated Annual Dose to the General Public MEI at the K-25 Site from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (exposures would result from airborne emissions and discharge of wastewater)

4.3.1.1.2 Cylinder Transfer Option

The collective dose to involved workers would range from 20 to 24 person-rem/yr for approximately 31 to 42 workers at the K-25 site. The average individual dose to involved workers would be less than 660 mrem/yr, corresponding to an LCF risk of 3×10^{-4} per year (one chance in 3,300 per year).

Radiation doses to noninvolved workers vary depending on the processing rate of cylinders, site-specific meteorological conditions, and distribution and population of the on-site workers (for collective doses). The estimated radiation dose to the MEI would be extremely small, less than 8×10^{-6} mrem/yr, due to the small airborne emission rates of uranium. Impacts to the off-site public would also depend on the factors discussed for noninvolved workers, but instead of the distribution and population of the on-site workers, the impacts would be determined by the distribution and population of the off-site public (for collective dose).

The radiation dose to the MEI of the off-site public would be greater than that for the MEI of the noninvolved workers because of the assumed additional exposure from drinking surface water. The radiation dose from drinking surface water would be greater than that from airborne emissions. The radiation doses to the off-site public MEI from normal operations of the cylinder transfer facility were estimated to be less than 4.4×10^{-5} mrem/yr, which is extremely small compared with the regulatory limit of 100 mrem/yr.

4.3.1.1.3 Preparation of Standard Cylinders

The collective radiation exposures to involved workers were estimated to range from 0 to 1.4 person-rem/yr for the K-25 site. The lower range results from the assumption that all the cylinders at the site would be problem cylinders. A maximum of four workers would be required for the preparation activities. The average individual dose to involved workers was estimated to be less than 600 mrem/yr.

4.3.1.2 Chemical Impacts

The only potential chemical impacts that could be associated with cylinder preparation options would be from exposure to emissions from a cylinder transfer facility; no impacts during normal operations would be expected for the cylinder overcontainer option or preparation of standard cylinders because no releases would occur. Risks from normal operations were quantified on the basis of calculated hazard indices. Information on the exposure assumptions, health effects assumptions, reference doses, and calculational methods used in the chemical impact analysis is provided in Appendix C of the PEIS and Cheng et al. (1997).

During cylinder transfer operations, very small quantities of UO_2F_2 effluent would be discharged into the air and surface water. Estimates of the hazardous chemical human health impacts resulting from cylinder transfer operations were calculated for the range of cylinders that might require processing at the site (i.e., up to 234 annually at K-25). Inhalation of HF was not included in the hazard index calculations because HF emissions from the cylinder transfer facility would be hundreds of times lower than HF emissions from conversion facilities (see Appendix F of the PEIS), for which no chemical impacts were predicted.

No impacts to noninvolved workers or the general public would be expected from normal transfer facility operations. The maximum (high case) hazard index for chemical impacts to the noninvolved worker MEI working at the cylinder transfer facility would be less than or equal to 1.1×10^{-8}. This value is considerably below the threshold for adverse effects (i.e., the ratio of intake to reference dose is much less than 1). The maximum (high case) hazard index for chemical impacts to the general public MEI would be less than or equal to 3.6×10^{-6}; this value is also considerably below the threshold for adverse effects.

4.3.2 Human Health — Accident Conditions

A range of accidents covering the spectrum of high-frequency/low-consequence accidents to low-frequency/high-consequence accidents has been presented in the engineering analysis report (LLNL 1997). These accidents are listed in Table 4.2. The results for the radiological and chemical health impacts of the maximum-consequence accident in each frequency category are presented in Sections 4.3.2.1 and 4.3.2.2. The bounding accidents are the same for both the cylinder overcontainer

TABLE 4.2 Accidents Considered for the Cylinder Preparation Options

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Cylinder Overcontainers					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, three full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Incredible Accidents (frequency: less than 1 time in 1 million years)					
Small plane crash, two full 48G cylinders[b]	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,190	0 to 30 30 to 121	Ground
Cylinder Transfer					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Cylinder valve shear	A single UF_6 cylinder is mishandled, etc., resulting in shearing of the cylinder valve and loss of solid UF_6 from the valve onto the ground.	UF_6	0.25	120 (continuous)	Ground
UF_6 vapor leak	A UF_6 transfer line leaks 5% of its flowing contents for 10 minutes due to potential compressor or pipe leakage.	UO_2F_2 HF	0.009 2.4	30	Stack
UF_6 liquid leak	A drain line from the UF_6 condensers leaks 5% of its flowing contents due to potential condenser or pipe leakage.	UO_2F_2 HF	0.0045 1.2	30	Stack
Loss of off-site electrical power	Off-site power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA	NA	NA
Loss of cooling water	Cooling water flow to the UF_6 condenser is lost, and UF_6 vapor is released.	UO_2F_2 HF	0.009 2.4	2	Stack

TABLE 4.2 (Cont.)

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Cylinder Transfer (Cont.)					
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
UF_6 cold trap rupture	A UF_6 cold trap is overfilled with UF_6 and ruptures during heating, releasing UF_6 into the process building.	UO_2F_2 HF	0.13 34	30	Stack
Extremely Unlikely Accidents (frequency: from 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, three full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Earthquake	A UF_6 compressor discharge pipe is cleanly sheared during a design-basis earthquake and leaks for 1 minute.	UO_2F_2 HF	0.018 4.7	30	Stack
Tornado	A design-basis tornado does not result in significant releases because UF_6 is a solid at ambient conditions.	No release	NA	NA	NA
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude flooding.	No release	NA	NA	NA
Small plane crash, two full 48G cylinders	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,192	0 to 30 30 to 121.4	Ground

[a] Ground-level releases were assumed to occur outdoors on concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

option and the cylinder transfer option. Results for all accidents listed in Table 4.2 are presented in Policastro et al. (1997). Detailed descriptions of the methodology and assumptions used in these calculations are also provided in Appendix C of the PEIS and Policastro et al. (1997).

4.3.2.1 Radiological Impacts

Table 4.3 lists the radiological doses to various receptors for the accidents that give the highest dose from each frequency category. The LCF risks for these accidents are given in Table 4.4. The doses and the risks are presented as ranges (maximum and minimum) because two different meteorological conditions were considered for each cylinder preparation option (see Appendix C of the PEIS). The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely category have a probability of occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.

- The maximum radiological dose to noninvolved worker and general public MEIs (assuming an accident occurred) would be 0.077 rem. This dose is less than the 25-rem dose recommended by the NRC (1994) for assessing the adequacy of protection of public health and safety from potential accidents.

- The overall radiological risk to noninvolved worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table 4.4] by the annual probability of occurrence by the number of years of operation) would be less than 1 for all of the accidents.

4.3.2.2 Chemical Impacts

The accidents considered for the cylinder preparation options are listed in Table 4.2. The results of the accident consequence modeling for chemical impacts are given in Tables 4.5 and 4.6. The results are presented as the (1) number of persons with potential for adverse effects and (2) the number of persons with potential for irreversible adverse effects. The results are given for the accident within each accident frequency category that would affect the largest number of persons (total of workers and off-site population) (Policastro et al. 1997). The impacts presented here are based on the assumption that the accidents would occur. The accidents listed in Tables 4.5 and 4.6 are not identical because an accident with the largest impacts for adverse effects might not lead to

TABLE 4.3 Estimated Radiological Doses per Accident Occurrence for the Cylinder Overcontainer and Cylinder Transfer Options at the K-25 Site

		Maximum Dose[c]				Minimum Dose[c]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Accident[a]	Frequency Category[b]	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	1.3	2.7×10^{-3}	4.3×10^{-1}	3.3×10^{-3}	6.0×10^{-2}	1.1×10^{-4}	5.9×10^{-2}
UF_6 cold trap rupture[d]	U	1.0×10^{-7}	1.8×10^{-4}	1.1×10^{-7}	1.2×10^{-3}	2.1×10^{-8}	3.6×10^{-5}	8.6×10^{-8}	5.0×10^{-4}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.6×10^{1}	1.3×10^{-2}	6.3×10^{1}	3.7×10^{-3}	2.4	1.9×10^{-3}	2.2
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	5.4	4.3×10^{-3}	7.4×10^{-1}	8.7×10^{-4}	6.9×10^{-1}	7.1×10^{-4}	1.0×10^{-1}

[a] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[b] Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} – 10^{-4}/yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} – 10^{-6}/yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations (< 10^{-6}/yr).

[c] Maximum and minimum doses reflect differences in assumed meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

[d] Applicable only to the cylinder transfer option.

TABLE 4.4 Estimated Radiological Health Risks per Accident Occurrence for the Cylinder Overcontainer and Cylinder Transfer Options at the K-25 Site[a]

Accident[b]	Frequency Category[c]	Maximum Risk[d] (LCFs)				Minimum Risk[d] (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
Corroded cylinder spill, dry conditions	L	3×10^{-5}	5×10^{-4}	1×10^{-6}	2×10^{-4}	1×10^{-6}	2×10^{-5}	6×10^{-8}	3×10^{-5}
UF_6 cold trap rupture[e]	U	4×10^{-11}	7×10^{-8}	6×10^{-11}	6×10^{-7}	8×10^{-12}	1×10^{-8}	4×10^{-11}	3×10^{-7}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	7×10^{-6}	3×10^{-2}	1×10^{-6}	9×10^{-4}	1×10^{-6}	1×10^{-3}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	2×10^{-3}	2×10^{-6}	4×10^{-4}	3×10^{-7}	3×10^{-4}	4×10^{-7}	5×10^{-5}

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCF) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.0001; incredible (I) = 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[c] Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} – 10^{-4}/yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} – 10^{-6}/yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations (< 10^{-6}/yr).

[d] Maximum and minimum risks reflect differences in assumed meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] Applicable only to the cylinder transfer option.

TABLE 4.5 Number of Persons with Potential for Adverse Effects from Accidents under the Cylinder Overcontainer and Cylinder Transfer Options at the K-25 Site[a]

		Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Accident[b]	Frequency Category[c]	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Corroded cylinder spill, dry conditions	L	Yes	69	No	0	Yes[f]	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	700	Yes	18	Yes	47	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	770	Yes	550	No	0	Yes	12
Small plane crash, 2 full 48G cylinders	I	Yes	420	Yes	34	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} – 10^{-4}/yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} – 10^{-6}/yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations (< 10^{-6}/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential adverse effects to an individual.

[f] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

TABLE 4.6 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Cylinder Overcontainer and Cylinder Transfer Options at the K-25 Site[a]

		Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Accident[b]	Frequency Category[c]	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Corroded cylinder spill, dry conditions	L	Yes	3	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	140	Yes[g]	0	Yes	2	No	0
Vehicle-induced fire, 3 full 48G cylinders[f]	EU	No	0	No	0	No	0	No	0
Small plane crash, 2 full 48G cylinders[f]	I	No	0	No	0	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L) = 0.1; unlikely (U) = 0.001; extremely unlikely (EU) = 0.00001; incredible (I) = 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site population) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L) = estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); unlikely (U) = estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} – 10^{-4}/yr); extremely unlikely (EU) = estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} – 10^{-6}/yr); incredible (I) = estimated to occur less than one time in 1 million years of facility operations (< 10^{-6}/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident, assumed to occur at the cylinder storage yard closest to the site boundary. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential irreversible adverse effects to an individual.

[f] These accidents would result in the largest plume size for the frequency category, although no people would be affected.

[g] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

the largest impacts for irreversible adverse effects. The following general conclusions may be drawn from the chemical accident assessment:

- If the accidents identified in Table 4.5 and 4.6 did occur, the number of persons in the off-site population with potential for adverse effects would range from 0 to 550 (maximum corresponding to the vehicle-induced fire scenario), and the number of off-site persons with potential for irreversible adverse effects would be 0.

- If the accidents identified in Tables 4.5 and 4.6 did occur, the number of noninvolved workers with potential for adverse effects would range from 0 to 770 (maximum corresponding to the vehicle-induced fire scenario), and the number of noninvolved workers with potential for irreversible adverse effects would range from 0 to 140 (maximum corresponding to the corroded cylinder spill under rain conditions).

- Accidents resulting in a vehicle-induced fire involving three 48G cylinders during very stable (nighttime) meteorological conditions would have a very low probability of occurrence but could affect a large number of people.

- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years of operations (20 years, 2009–2028). The results indicate that the maximum risk values would be less than 1 for all accidents, except the following:

  - *Potential Adverse Effects and Irreversible Adverse Effects:*

    Corroded cylinder spill, dry conditions (L, likely), workers

    Corroded cylinder spill, wet conditions – rain (U, unlikely), workers

These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated potential irreversible effects was estimated. All the bounding-case accidents shown in Table 4.6 would involve releases of UF_6 and potential exposure to HF and uranium compounds. These exposures could be high enough to result in death for up to 1% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). This would mean that for workers experiencing a range of 0 to 140 irreversible adverse effects, approximately 0 to 1 death would be expected. These are the maximum potential consequences of the accidents; the upper ends of the ranges result from the assumption of worst-case weather conditions, with the wind blowing in the direction where the highest number of people would be exposed.

4.3.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries for involved and noninvolved workers is calculated using industry-specific statistics from the Bureau of Labor Statistics, as reported by the National Safety Council (1995). Construction and manufacturing annual fatality and injury rates were used respectively for the construction and operational phases of the cylinder transfer facility lifetime; manufacturing fatality and injury rates were used for standard cylinder shipping preparation and overcontainer activities.

Figure 4.10 shows the fatality and injury incidences for all workers associated with packaging cylinders in overcontainers across the ranges that might be required at the site (i.e., 120 to 234 cylinders/yr). The impacts would increase directly as a function of the numbers of cylinders placed in overcontainers annually. Fatality incidence over the 20-year period of operations would be less than 1 — ranging from about 0.007 to 0.014 at K-25. On the basis of the ranges given for overcontainer requirements, the corresponding estimated injury incidence over the 20-year operations period would be from about 9 to 18.

Figures 4.11 and 4.12 give the fatality and injury incidences for all workers associated with transferring cylinder contents to new cylinders across the same potential range requirements as discussed above. It was assumed that any transfer facility would be constructed with a capacity near to or somewhat greater than the maximum number of cylinders expected to require processing (the actual numbers would not be determined until the time of cylinder shipment). Data in the engineering analysis report (LLNL 1997) showed that the relationship between number of cylinders processed annually and number of employees required per cylinder processed would not increase linearly. For example, more employees per cylinder would be required to process 100 cylinders than to process 1,000 cylinders. Fatality incidence for transfer facility construction and operation would be less than 1, ranging from about 0.17 to 0.21. On the basis of the assumed range in cylinder transfer requirements given above, the corresponding injury incidence would range from about 94 to 140 at K-25.

Figure 4.13 gives the fatality and injury incidences for all workers associated with preparation of standard cylinders for transport across the range that might be required at the site (i.e., 0 to 120 cylinders/yr). The impacts would increase directly as a function of the numbers of cylinders prepared annually. Fatality incidence would be less than 1, ranging from 0 to about 0.006. The corresponding injury incidence would range from 0 to about 7 injuries.

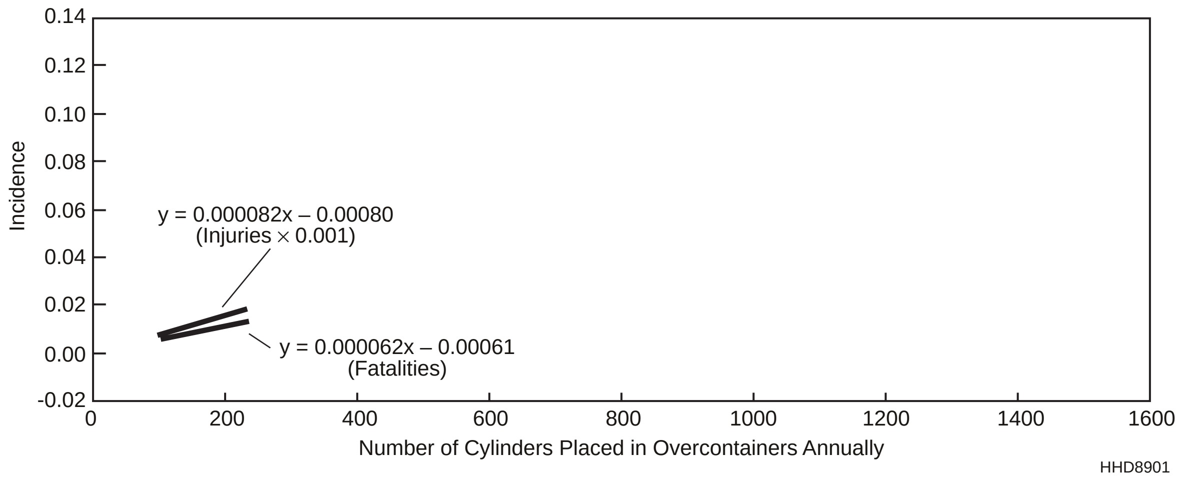

FIGURE 4.10 Worker Fatality and Injury Incidence for Cylinder Overcontainer Activities

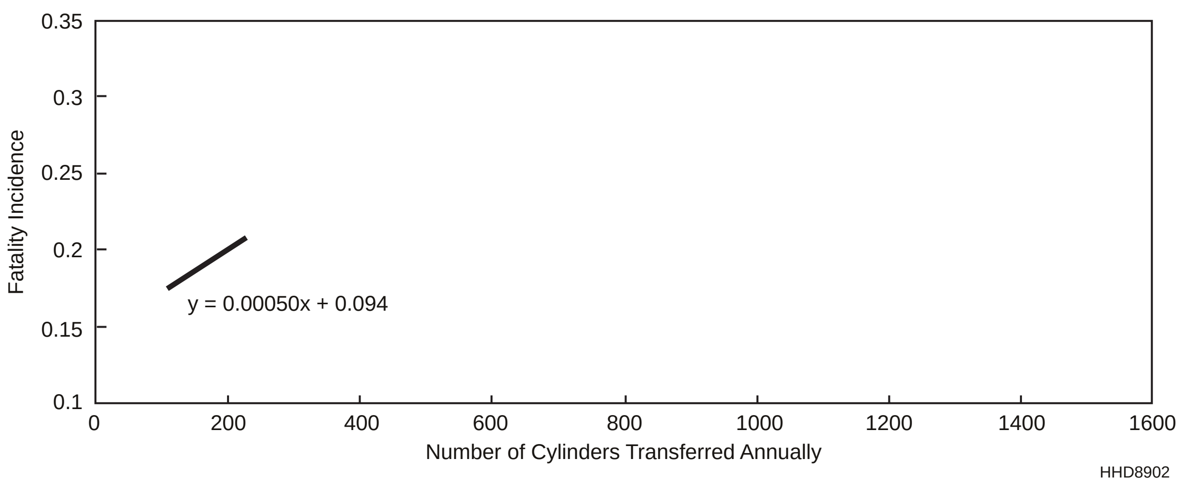

FIGURE 4.11 Worker Fatality Incidence for Cylinder Transfer Activities

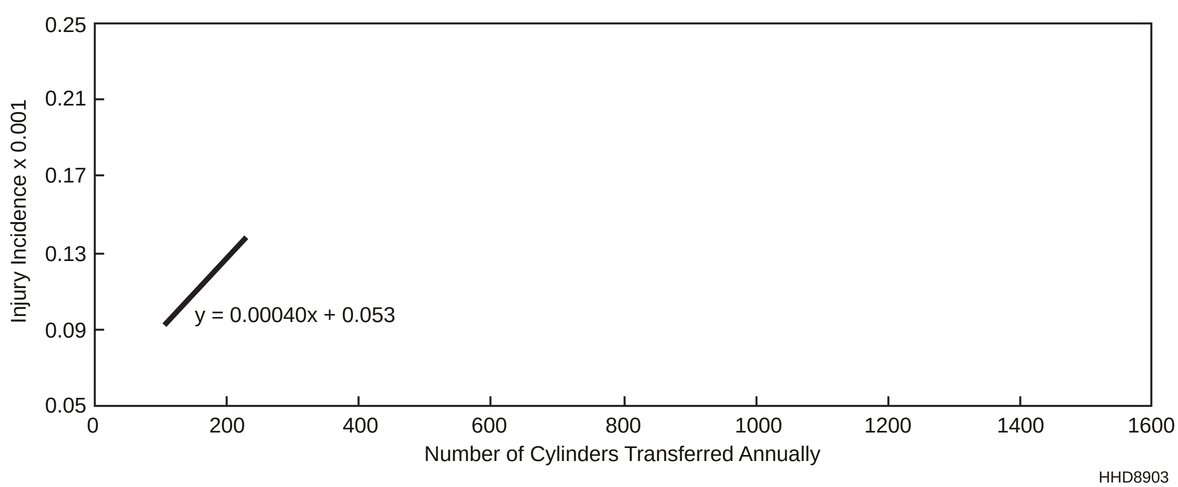

FIGURE 4.12 Worker Injury Incidence for Cylinder Transfer Activities

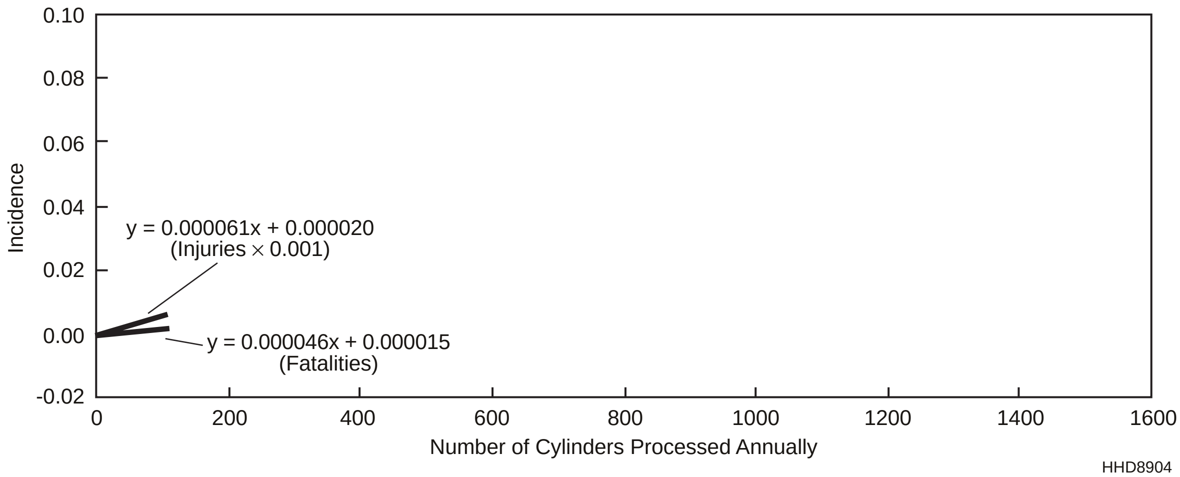

FIGURE 4.13 Worker Fatality and Injury Incidence for Standard Cylinder Preparation

4.3.3 Air Quality

Air quality impacts would result from the emissions associated with two distinct cylinder preparation options: (1) movement of cylinders in preparation for transportation (both cylinders requiring overcontainers and standard cylinders) and (2) construction and operation of facilities to transfer contents from substandard cylinders to new ones. These two options are referred to in the following discussion as “overcontainer” and “transfer facility.” No construction would be required for the overcontainer option. Descriptions of the methodology and assumptions are provided in Appendix C of the PEIS and Tschanz (1997a).

The air quality impacts of cylinder preparation options at the K-25 site are shown in Table 4.7. The impacts of criteria pollutant emissions during operation of the transfer facility would be negligible. Process stack emissions during operations would produce an annual average HF concentration of 1.3×10^{-5} : g/m^3 and UO_2F_2 concentration of 1.0×10^{-6} : g/m^3.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the K-25 site. Anderson and Roane Counties in the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Region are currently in attainment for all criteria pollutant standards, including ozone. The pollutant emissions most related to ozone formation that could result from the cylinder preparation options at the K-25 site would be HC and NO_x. The potential effects on ozone of those pollutants can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in Anderson and Roane Counties, as recorded in the Tennessee Division of Air Pollution Control “Emissions Inventory” for 1995 (Conley 1996). The estimated HC and NO_x emissions of 0.14 and 1.20 tons/yr during operation of the cylinder transfer facility would be only 0.005 and 0.002%, respectively, of the 1995 two-county emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone

TABLE 4.7 Air Quality Impacts of Cylinder Preparation Options at the K-25 Site

	Estimated Maximum Pollutant Concentrations from the Overcontainer Option							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Range (: g/m^3)	Fraction of Standard[a]	Range (: g/m^3)	Fraction of Standard[a]	Range (: g/m^3)	Fraction of Standard[a]	Range (: g/m^3)	Fraction of Standard[a]
CO	3.6 – 4.5	0.00011	0.54 – 0.67	0.00007	0.23 – 0.29	–	0.017 – 0.021	–
NO_x	0.56 – 0.70	–	0.083 – 0.10	–	0.036 – 0.044	–	0.0026 – 0.0033	0.00003
PM_{10}	0.11 – 0.14	–	0.016 – 0.020	–	0.0071 – 0.0088	0.00006	0.00052 – 0.00064	0.00001
	Estimated Pollutant Concentrations from Construction of the Cylinder Transfer Facility							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concentration (: g/m^3)	Fraction of Standard[a]	Concentration (: g/m^3)	Fraction of Standard[a]	Concentration (: g/m^3)	Fraction of Standard[a]	Concentration (: g/m^3)	Fraction of Standard[a]
CO	2,200	0.055	1,100	0.11	470	–	61	–
NO_x	320	–	160	–	69	–	8.9	0.089
PM_{10}	590	–	300	–	130	0.87	16	0.32

[a] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded. A hyphen indicates that no standard is available for this averaging period.

attainment status of the region. Emissions of HC and NO_x from the overcontainer option would be even smaller.

4.3.4 Water and Soil

The cylinder preparation options were assessed for potential impacts on surface water, groundwater, and soils. Details on the methodology and assumptions are presented in Appendix C of the PEIS and Tomasko (1997b).

4.3.4.1 Surface Water

Potential impacts to surface water for the cylinder preparation options could occur during construction, normal operations, and postulated accident scenarios. For the cylinder overcontainer option and preparation of standard cylinders, however, there would be no impacts to surface water because no liquid wastes would be produced during construction and operations (LLNL 1997) and no accident scenarios were identified in the engineering analysis report that would directly release contaminated material to surface water (LLNL 1997). Secondary impacts to surface water would also be negligible because of the small concentrations associated with air deposition.

For the cylinder transfer facility, potential impacts to surface water during construction, normal operations, and accident scenarios would include changes in runoff, changes in quality, and floodplain encroachment.

4.3.4.1.1 Construction

Construction of a cylinder transfer facility with a capacity of 320 cylinders per year at the K-25 site would increase runoff because about 8 acres (4 ha) of land would be replaced with paved lots and buildings (Table 4.8). This increase in impermeable surface would produce a negligible impact on runoff because of the size of the existing watershed (0.5% of the land available).

Construction of the cylinder transfer facility would require about 6.5 million gal/yr (12 gal/min or gpm) of water. This withdrawal would correspond to about 0.00059% of average river flow and would produce a negligible impact on water levels and floodplains. During construction, about 3.3 million gal/yr (6 gpm) of wastewater would be discharged to the river. Because of dilution (340,000:1), contaminant concentrations would be reduced to considerably below regulatory standards.

4.3.4.1.2 Operations

For normal operation of the 320/yr cylinder transfer facility at the K-25 site, about 6 million gal/yr (11 gpm) of water would be required (Table 4.8). This rate of withdrawal would represent about 0.00054% of the average river flow and would produce a negligible impact on water levels and floodplains.

TABLE 4.8 Summary of Environmental Parameters for the Cylinder Transfer Facility

Option	Amount Involved
Disturbed land area (acres)	12
Paved area (acres)	8
Construction water (million gal/yr)	6.5
Construction wastewater (million gal/yr)	3.3
Operations water (million gal/yr)	6
Operations wastewater (million gal/yr)	4.4
Radioactive release (Ci/yr)	0.00049

About 4.4 million gal/yr (8 gpm) of wastewater would be discharged to the river. This water would consist of sanitary wastewater, blowdown water, industrial wastewater, and process water (LLNL 1997). This discharge would represent about 0.00038% of the average river flow and would produce a negligible impact on water levels and floodplains.

Normal operations would also impact surface water quality. Approximately 0.00049 Ci/yr of uranium would be released to surface water (about 112 :g/L at the point of discharge). Although the concentration of uranium at the outfall would exceed the 20 :g/L guideline (EPA 1996), the resulting uranium concentration (as well as other chemicals) in the river would be less than 20 :g/L because of dilution (255,000:1).

4.3.4.1.3 Accident Scenarios

No accidents are identified in LLNL (1997) that would directly affect surface water at the site. Secondary impacts resulting from deposition of airborne contaminants would not be measurable because of low concentrations in the deposited material.

4.3.4.2 Groundwater

For the cylinder overcontainer option and during preparation of standard cylinders, there would be no impacts to groundwater at the site because there would be no discharges to the surface (LLNL 1997). For the cylinder transfer facility, impacts could occur during construction and normal operations; however, there would be no impacts from potential accidents because no accidents were identified in the engineering analysis report (LLNL 1997) that would release contaminants to the ground. Secondary impacts from air deposition would not be measurable because of the small concentrations of deposited material.

4.3.4.2.1 Construction

Construction of the cylinder transfer facility would decrease the permeability of about 8 acres (3.2 ha) (Table 4.8). This loss of permeable land would reduce recharge, increase depth to the water table, and change the direction of groundwater flow; however, because the affected area would be small (about 0.5% of the land available), the impacts would be local and negligible. During construction, groundwater quality would also be impacted. By following good engineering and construction practices, groundwater concentrations would be less than the EPA guidelines.

4.3.4.2.2 Operations

No impacts to groundwater would occur during normal operations at the K-25 site because no groundwater would be used and there would be no discharges to the ground.

4.3.4.2.3 Accident Scenarios

No accidents associated with cylinder preparation options were identified in LLNL (1997) that would potentially release contaminants to groundwater.

4.3.4.3 Soil

For the cylinder overcontainer option and during preparation of standard cylinders, there would be no impacts to soils because there would be no discharges to the ground. For the cylinder transfer facility, the only impacts would occur during construction; for normal operations, there would be no discharges to the ground, and there are no accidents identified in the engineering analysis report (LLNL 1997) that would lead to direct contamination of the soil. Secondary impacts to the soil from air deposition would be negligible because of the small concentrations of contaminants in the deposited material. Impacts from construction of the cylinder transfer facility include changes in topography, permeability, quality, and erosion potential.

At the K-25 site, construction of a cylinder transfer facility with a capacity for 320 cylinders per year would disturb 12 acres (4.9 ha) of land (Table 4.8). In the area of the construction, topography would be altered, permeability would be decreased in paved areas or areas that were compacted, permeability would increase in aerated areas, and erosion potential would decrease in compacted areas and increase in areas that were aerated. In general, these impacts would be negligible because the affected area would be small (about 0.7% of the land available), and in many cases, the impacts would be temporary (with regrading and reseeding, the soil would return to its former condition).

In addition to these changes, construction could also have a chemical impact on soil. By following good engineering and construction practices, impacts to soil quality would be negligible.

4.3.5 Socioeconomics

The impacts of cylinder preparation on socioeconomic activity were estimated for an ROI around the K-25 site. Additional details regarding the assessment methodology is presented in Appendix C of the PEIS and Allison and Folga (1997).

Cylinder preparation would likely have a small impact on socioeconomic conditions in the ROI surrounding the site, described in Section 2.8. This is partly because a major proportion of expenditures associated with procurement for the preoperation and operation of each preparation option would flow outside the ROI to other locations in the United States, reducing the concentration of local economic effects of each facility.

Slight changes in employment and income would occur in the ROI as a result of local spending of personal consumption expenditures derived from employee wages and salaries, local procurement of goods and services required for cylinder preparation activities, and other local investment associated with preoperations and operations. In addition to creating new (direct) jobs at the site, cylinder preparation would also create indirect employment and income in the ROI as a result of jobs and procurement expenditures at the site. Jobs and income created directly by cylinder preparation, together with indirect activity in the ROI, would contribute slightly to a reduction in unemployment in the ROI surrounding the site. Minimal impacts would be expected on local population growth and, consequently, on local housing markets and local fiscal conditions.

The effects of preoperating and operating cylinder preparation on regional economic activity, measured in terms of employment and personal income, and on population, housing, and local public revenues and expenditures are discussed in Sections 4.5.1 through 4.5.3. Impacts are presented for cylinder preparation at the storage site for the peak year of preoperations; operations values are averages for the period 2009 through 2028. The impacts of cylinder preparation are given in Table 4.9.

4.3.5.1 Impacts from Cylinder Preparation Using Overcontainers

During the peak year of preoperations for cylinder preparation using overcontainers, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table 4.9) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with $0.2 million of total income produced during the peak year. During the first year of operations involving overcontainers,

TABLE 4.9 Potential Socioeconomic Impacts of the Cylinder Preparation Options at the K-25 Site

Parameter	Cylinder Overcontainers		Cylinder Transfer Facility		Standard Cylinder Preparation	
	Preoperation[a]	Operations[b]	Construction[a]	Operations[b]	Preoperation[a]	Operations[b]
Economic activity in the ROI						
Direct jobs	<5	80	130	130	<5	40
Indirect jobs	<5	120	160	380	<5	60
Total jobs	<5	200	290	510	<5	100
Direct income ($ million)	0.1	5	6	7	0.1	2
Total income ($ million)	0.2	6	9	13	0.1	3
Population in-migration into the ROI	<5	190	220	240	<5	80
Housing demand						
Number of units in the ROI	<5	70	80	90	<5	30
Public finances						
Change in ROI fiscal balance (%)	0	0.1	0.04	0.04	0	0.01

[a] Impacts are for peak year of preoperation or construction, 2007. The preoperational (construction) phase was assessed from 1999 through 2008.
[b] Impacts are the annual averages for operations for the period 2009 through 2028.

200 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $6 million in total income produced. Activities associated with overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage point from 1999 through 2028.

Preoperations involving overcontainers would be expected to generate direct in-migration of fewer than 5 in the peak year (Table 4.9). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for cylinder overcontainers would be expected to generate direct and indirect job in-migration of 190 in the first year of operations. Preoperational and operational activities for overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.03 percentage point from 1999 through 2028.

Cylinder overcontainer activities would generate a demand for fewer than 5 additional rental housing units during the peak year of preoperations, representing an impact of 0.1% on the projected number of vacant rental housing units in the ROI. A demand for 70 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.6% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table 4.9). In the first year of operations, 190 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

4.5.3.2 Impacts from a Cylinder Transfer Facility

During the peak year of construction of a cylinder transfer facility, 130 direct jobs would be created at the site and 160 additional jobs indirectly in the ROI (Table 4.9) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 290 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with $9 million of total income produced during the peak year. During the first year of operations of the cylinder transfer facility, 510 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $13 million in total income produced. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage point from 1999 through 2028.

Construction of the cylinder transfer facility would be expected to generate direct in-migration of 170 in the peak year (Table 4.9). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to 220 in the peak year. Operation of the cylinder transfer facility would be expected to generate direct and indirect job in-migration of 240 in the first year of operations. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.004 percentage point from 1999 through 2028.

The cylinder transfer facility would generate a demand for 80 additional rental housing units during the peak year of construction, representing an impact of 1.5% on the projected number of vacant rental housing units in the ROI (Table 4.9). A demand for 90 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.8% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 220 people would be expected to in-migrate into the ROI, leading to an increase of 0.04% over ROI-forecasted baseline revenues and expenditures (Table 4.9). In the first year of operations, 240 in-migrants would be expected, leading to an increase of 0.04% in local revenues and expenditures.

4.3.5.3 Impacts from Standard Cylinder Preparation

During the peak year of preoperational activities for standard cylinder preparation, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table 4.9) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with $0.1 million of total income produced during the peak year. During the first year of operations for standard cylinder preparation, 100 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $3 million in total income produced. Preoperational and operational activities for standard cylinder preparation would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage point from 1999 through 2028.

Preoperational activities for standard cylinder preparation would be expected to generate direct in-migration of fewer than 5 in the peak year (Table 4.9). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for cylinder preparation would be expected to generate direct and indirect job in-migration of 80 in the first year of operations. Preoperational and operational activities would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.001 percentage point from 1999 through 2028.

Standard cylinder preparation activities would generate a demand for fewer than 5 additional rental housing unit during the peak year of preoperations, representing essentially no impact on the projected number of vacant rental housing units in the ROI (Table 4.9). A demand for 30 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.3% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table 4.9). In the first year of operations, 80 in-migrants would be expected, leading to an increase of 0.01% in local revenues and expenditures.

4.3.6 Ecology

Predicted concentrations of contaminants in environmental media were compared with benchmark values of toxic and radiological effects to assess impacts to terrestrial and aquatic biota. Discussion of assessment methodology is presented in Appendix C of the PEIS.

No ecological impacts would be expected during preparation of standard cylinders. Under the cylinder overcontainer option, no site preparation or construction would occur. Normal operations would not result in impacts to surface water, groundwater, or soil (Section 4.3.4). Atmospheric releases of contaminants would include only criteria pollutants, and emission levels would be expected to be extremely low (Section 4.3.3). Therefore, impacts of the cylinder overcontainer option to ecological resources would be negligible.

Impacts to ecological resources could result from construction of a cylinder transfer facility. Impacts could include mortality of individual organisms, habitat loss, or changes in biotic communities. Impacts due to operation of a cylinder transfer facility could result from exposure to airborne contaminants or contaminants released to soils, groundwater, or surface waters or changes in surface water or groundwater quality or flow rates.

Construction of a transfer facility would disturb approximately 12 acres (5 ha), including the permanent replacement of 8 acres (3 ha), primarily with structures and paved areas. Construction would not be expected to threaten the local population of any species. The loss of up to 12 acres (5 ha) of undeveloped land and 9 to 12 acres (4 to 5 ha) of habitat would constitute a moderate adverse impact to vegetation and wildlife.

The low atmospheric emissions of contaminants from cylinder preparation activities would result in negligible impacts to biota. Uranium concentrations in discharges to surface water would also be low, resulting in negligible impacts to aquatic biota.

4.3.7 Waste Management

Estimates of waste generation were based on the total number of cylinders at the K-25 site. No liquid wastes would be expected as a result of cylinder shipment activities from either standard cylinders or cylinders in overcontainers. The only solid waste generated in these activities would be personal protective equipment and wipes and rags that would be used to remove surface contamination on the cylinders. These wastes are categorized as combustible solid LLW and are shown in Table 4.10. It was assumed that the LLW would be generated during removal of surface contamination and would be independent of the cylinders being standard or substandard. Thus, the amount of waste in this operation would be proportional to the total number of cylinders at the site. It was assumed that no cylinder breaches would occur inside the overcontainers during transportation.

The waste input resulting from the cylinder overcontainer operations would have minimal impact on radioactive waste management capabilities at the site or on a national level. The impact on site nonradiological waste management would also be negligible.

The estimated total quantities of solid and liquid wastes generated from activities associated with the construction of the 320-cylinder/yr-capacity cylinder transfer facility are shown in Table 4.11. A facility with this capacity would represent the upper end of the range of cylinders that might require preparation at the K-25 site. The type and quantity of solid and liquid waste expected to be generated from the operation of the cylinder transfer facility are shown in Table 4.12, based on a throughput cylinder capacity of 5% of the total cylinder inventory at each site. The different types of waste generated during the operation of this facility would include LLW, LLMW, hazardous waste, and nonhazardous waste.

The primary waste produced in the transfer process would be empty UF_6 cylinders and grouted waste drums. Radioactive or hazardous liquid materials would include decontamination liquids, laboratory liquid wastes,

TABLE 4.10 Waste Generated with Activities for Cylinder Overcontainers or Standard Cylinder Preparation[a]

Waste Type[b]	Annual Volume (m^3/yr)	Uranium Form
LLW (combustible solids)	2.8	UO_2F_2

[a] Decontamination of the overcontainer surfaces was assumed to be performed at the conversion/storage facility prior to the overcontainer being sent back to the site for reuse.

[b] It was assumed that the low-level waste would be generated during removal of surface contamination and would be independent of the cylinder being standard or substandard.

TABLE 4.11 Total Wastes Generated during Construction of a Cylinder Transfer Facility with a 320-Cylinder/yr Capacity

Waste Category	Quantity
Hazardous solids	31 m^3
Hazardous liquids	15,000 gal
Nonhazardous solids	
Concrete	58 m^3
Steel	30 tons
Other	610 m^3
Nonhazardous liquids	
Sanitary	2.3 million gal
Other	1 million gal

Source: LLNL (1997).

TABLE 4.12 Estimated Annual Radioactive, Hazardous, and Nonhazardous Wastes Generated during Operation of the Cylinder Transfer Facility at the K-25 Site

Type of Waste	Description of Waste	Annual Volume (m^3)	Contaminants
Low-Level Waste			
Combustible solids	Gloves, wipes, clothing, etc.	15	17 lb UO_2F_2
Metal, surface-contaminated	Failed equipment	2.2	16 lb UO_2F_2
Noncombustible compactible solids	HEPA filters	8.0	54 lb UO_2F_2
	Grouted waste	0.44	135 lb $UO_2(OH)_2$
Other	Lab packs (chemicals)	0.11	0.75 lb UO_2F_2
Low-Level Mixed Waste			
Lab packs	Chemicals	0.04	0.37 lb UO_2F_2
Inorganic process debris	Failed equipment	0.04	0.37 lb UO_2F_2
Combustible debris	Wipes, etc.	0.04	0.07 lb UO_2F_2
Hazardous Waste			
Organic liquids	Solvents, oil, paint, thinner	0.18	
Inorganic process debris	Failed equipment	0.26	1.5 lb HF, 2 lb NaOH
Combustible debris	Wipes, etc.	0.26	0.75 lb HF, 1 lb NaOH
Nonhazardous Waste			
Nonhazardous solid waste	Nonhazardous solid waste	20	
Nonhazardous liquid waste	Cooling tower blowdown process water, etc.	76	
Recyclable waste	Recyclable waste	30	

Notation: HEPA = high-efficiency particulate air (filters); HF = hydrogen fluoride; NaOH = sodium hydroxide; UO_2F_2 = uranyl fluoride; $UO_2(OH)_2$ = uranyl hydroxide.

contaminated cleaning solution, lubricants, and paints. Radioactive or hazardous solid wastes would include failed process equipment, high-efficiency particulate air (HEPA) filters, laboratory wastes, wipes, rags, and operator-contaminated clothing. The LLW would be shipped off-site for disposal, and the LLMW and hazardous waste would be shipped off-site for both treatment and disposal. The total volume of crushed, empty UF_6 cylinders from the K-25 site would be about 130,000 m^3. It was assumed that the treated cylinders would become part of the DOE scrap metal inventory. If a disposal decision were made, the treated cylinders could be disposed of as LLW, representing less than 1% addition to the total projected DOE complexwide LLW disposal volume.

Overall, the waste input resulting from construction and operation of a transfer facility would add less than 7% to the K-25 site LLW (see Section 2.9). The input of LLMW and nonhazardous wastes from the transfer facility would represent less than 1% of the site's LLMW or nonhazardous waste loads.

The waste input resulting from the construction and operation of the transfer facility would have minimal impact on radioactive waste management capabilities at the site. The impact on nonradiological site waste management would also be negligible. The impacts of waste resulting from the operation of the depleted UF_6 transfer facility on national waste management capabilities would be negligible.

4.3.8 Resource Requirements

The approach taken for assessment of resource requirements was based on a comparison of required resources with national and state-level statistics on consumption of commodities (U.S. Department of Commerce 1997, 1999). More detailed information related to the methodology is presented in Appendix C of the PEIS.

Cylinder overcontainers would be constructed primarily from steel purchased from existing steel vendors. The preliminary overcontainer design requires approximately 8,000 lb (3,600 kg) of steel per overcontainer (LLNL 1997). Resources would be required only for the construction of overcontainers. No substantial resources would be required for the use of the overcontainers. Because the overcontainers would be reusable, it is estimated that the total number of overcontainers required would be approximately 60 (LLNL 1997). This total assumes a 10% contingency for spares, unforeseen delays, and the few overcontainers that might be needed at the cylinder treatment facility. The total amount of steel required for the overcontainers would be about 460,000 lb (210,000 kg). Based upon the total steel required for construction of overcontainers, no impact on local or national steel availability or production would be expected (Standard & Poor's 1996; U.S. Bureau of the Census 1996). No other materials of significant quantity would be required.

Resource needs for the cylinder transfer facility are presented in Table 4.13 as utilities consumed during construction and operations. The facility was assumed to operate 24 hours per day, 7 days per week, and 292 days per year for an 80% plant availability during operations.

The process equipment would be purchased from equipment vendors. The total quantities of commonly used construction material (i.e., steel) for equipment would be minor as compared to the quantities for construction. The primary specialty material used for equipment fabrication is at most approximately 7 tons of Monel. The material quantities required for construction and operation of the cylinder transfer facility would be minor compared to local and national supplies.

4.3.9 Land Use

No impacts to land use from cylinder overcontainer operations would be expected. No additional land would be required, and no new construction would be necessary. Existing handling and support equipment would be utilized with no modifications required (LLNL 1997). No off-site traffic impacts would be encountered during operations because the required labor force would not appreciably affect local traffic patterns or flows.

Impacts to land use from the construction and operation of a cylinder transfer facility would be negligible and limited to temporary disruptions to contiguous land parcels and potential minor traffic disruptions from peak year construction activities. Areal requirements would be small (approximately 21 acres or less).

The peak construction labor force for the cylinder transfer facility could result in potential off-site traffic impacts in the vicinity of the site, although such impacts would be negligible and would ease as construction neared completion.

4.3.10 Cultural Resources

No impacts to cultural resources would be expected at the K-25 site as a result of the cylinder overcontainer option for cylinder preparation. Impacts could result from the cylinder transfer option during construction of the transfer facility. Specific impacts cannot be determined at this time and would depend on the exact location of a facility within the site and whether eligible cultural resources existed on or near that location. Operation of the transfer facility would not affect cultural resources.

TABLE 4.13 Resource Requirements for Construction and Operation of the Cylinder Transfer Facility at the K-25 Site

Material/Resource	Total Requirement
Construction	
Utilities	
Electricity (GWh)	25
Solids	
Concrete (yd^3)	16,000
Steel (tons)	6,000
Liquids	
Fuel (million gal)	1.2
Gases	
Industrial gases (gal)	3,500
Specialty material (Monel) (tons)	4
Operations	
Utilities	
Electricity (GWh/yr)	7.1
Solids (lb)	
Cement	530
Potassium hydroxide	930
Liquids	
Sulfuric acid (lb/yr)	470
Hydrochloric acid (lb/yr)	970
Sodium hydroxide (lb/yr)	770
Liquid fuel (gal/yr)	4,800
Gases	
Natural gas (million scf/yr[a])	26

[a] scf = standard cubic feet.

4.3.11 Environmental Justice

The analysis of human health and environmental impacts associated with the cylinder overcontainer operations (Sections 4.3.1 through 4.3.9) indicates that no high and adverse human health effects would be expected at the K-25 site during normal operations. Consequently, no particular segment of the population, including minority and low-income persons, would be disproportionately affected. The results of accident analyses for cylinder preparation did not identify high and adverse impacts to the general public (i.e., the risk of accidents, consequence times probability, was less than 1).

The construction and operation of a cylinder transfer facility at the site would not result in disproportionate effects on minority or low-income populations. The analysis of human health effects and environmental impacts associated with a cylinder transfer facility (Sections 4.3.1 through 4.3.9) indicates that no high and adverse human health effects or environmental impacts would be expected.

4.3.12 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur if the cylinder preparation options were implemented include impacts to the visual environment (e.g., aesthetics), recreational resources, and noise levels, as well as impacts associated with decontamination and decommissioning of the cylinder transfer facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- Consideration of these impacts would not contribute to differentiation among the alternatives and therefore would not affect the decisions to be made in the ROD for the PEIS, or

- Impacts to the visual environment, recreational resources, and noise levels would be expected to stay the same as they are because cylinder preparation activities would be similar to the cylinder management activities currently ongoing at the K-25 site.

5 CUMULATIVE IMPACTS AT THE K-25 SITE

Cumulative impacts are those impacts that result from the incremental impact of an action (in this case, depleted UF_6 management) when added to the impacts of other past, present, and reasonably foreseeable future actions. To conduct the cumulative impacts analysis for this PEIS, DOE examined those impacts associated with depleted UF_6 management activities certain to occur at the K-25 site under all alternatives, which includes continued cylinder storage for some period for all alternatives and cylinder preparation for shipment for all alternatives except the no action alternative. To these impacts, DOE then added the impacts of other past, present, and reasonably foreseeable future actions in order to assess cumulative impacts. Non-DOE actions were considered when they would occur at the K-25 site, or when the nature of their impacts at a location near the site could increase impacts anticipated at the site itself.

5.1 CUMULATIVE IMPACT ISSUES AND ASSUMPTIONS

The cumulative impact analysis considered the following impact areas for existing operations, depleted UF_6 management options, and other reasonably foreseeable future actions:

- ***Health Risk***

  - Collective radiation dose and cancer risk for the general public over the 41-year period of depleted UF_6 operations,

  - Annual radiation dose for a hypothetical maximally exposed off-site individual,

  - Collective radiation dose and cancer risk for the worker population, and

  - Number of truck or rail shipments of radioactive materials to and from the site and the contributions to the dose to an MEI near the site gate;

- ***Environmental Quality***

  - Potential emissions that affect air quality compared to air quality standards and

  - Potential contaminants that affect groundwater quality concentrations compared to drinking water standards or other guideline values;

- ***Resource and Infrastructure Requirements***

  - Land requirements (presented as the percent of suitable land at the site occupied by existing facilities and needed for depleted UF_6 management activities and other future actions),

  - Percent of current water supply (presented as the percent of existing capacity needed for existing operations, depleted UF_6 management activities, and other future actions),

  - Percent of current wastewater treatment capacity (presented as the percent of existing capacity needed for existing operations, depleted UF_6 management activities, and other future actions), and

  - Percent of current power capacity (presented as the percent of existing capacity needed for existing operations, depleted UF_6 management activities, and other future actions).

The health risks to the off-site population are reported as collective exposures and risks for the entire period of conducting a particular operation, while the dose to the maximally exposed individual is reported as an annual value. Annual exposures are used for the maximally exposed individual to allow a direct comparison to the DOE maximum dose limit of 100 mrem/yr exposure to an individual of the general public (MEI) from all radiation sources and exposure pathways (DOE Order 5400.5). A cumulative impacts table containing the impact categories and the major elements composing the cumulative impacts is presented for the K-25 site. These elements include the existing conditions at the site, the maximum impacts of depleted UF_6 management activities analyzed in the PEIS, and the impacts of other reasonably foreseeable future actions.

The impact categories addressed as part of the cumulative impact analysis for the site are those associated with depleted UF_6 management that might generate noteworthy environmental effects when aggregated with the environmental consequences of other actions. Some impacts, such as impacts to ecological resources and cultural resources, were not included in the cumulative impact analysis because they are dependent on the specific facility location within the site boundary and location-specific environmental factors. Other impacts, such as impacts of accidents, were not included because it is highly improbable that accidents would occur together.

Cumulative impacts for the K-25 site were evaluated by adding the impacts of depleted UF_6 management options to the impacts of past, present, and reasonably foreseeable future actions at the site and in the region (primarily actions that DOE is considering for other programs). The latter include actions related to production and management of nuclear materials, management of nuclear fuel, research and development activities, and defense programs. To assess the effects of cumulative impacts, the estimated cumulative impacts calculated for the site were compared to regulatory levels for MEI exposures, air quality standards, and drinking water standards or guidelines for these parameters. If regulatory levels or guidelines would be exceeded, then the impact could be considered significant. LCFs among the public would be considered significant if the cumulative impacts of activities at the site would yield more than 1 LCF over the 41-year period. Because radiological exposure of workers would be maintained at or below regulatory levels, resulting LCFs to those individuals would be those corresponding to acceptable radiation doses. Resources and infrastructure impacts would be considered significant if the land area required, water use, wastewater production, or power demand approached 100% of capacity for the site.

Cumulative impacts also included the consequences of recent and current environmental restoration actions. The impacts of future environmental restoration actions were not included in the cumulative impact analysis because of insufficient characterization of the contamination and because proposals for particular actions are not yet final. Impacts of future environmental restoration activities at the site would be analyzed in later site-specific CERCLA/RCRA program documents.

Past impacts included in the cumulative impact analysis consist of past construction, development, and environmental restoration activities that contributed to existing conditions at the site and any past activities that may have resulted in current groundwater contamination at the site; these are presented as impacts of existing operations. Although dose reconstruction studies were conducted at several DOE sites, including the ORR, these studies have not progressed to the point that would allow incorporation of results in this report.

No assumptions are made regarding future baseline conditions at the site that could potentially reduce impacts, such as cessation of certain ongoing operations that would reduce current levels of radioactive releases. A number of other simplifying assumptions were made to estimate cumulative impacts regarding timing, site location, and consistency of analytical methods. Other existing or planned actions at the site were assumed to occur during the period of depleted UF_6 management operations. These other actions were assumed to be collocated with depleted UF_6 management facilities to the extent that they affect the same off-site population and MEI. These assumptions result in conservative analyses that overestimate actual cumulative impacts.

Some or most of the depleted UF_6 cylinder management activities currently occurring at the site (and considered under existing operations) would persist during continued storage and are included in the impacts of continued storage. When estimating cumulative impacts over the 41-year assessment period, no adjustment was made for this overlap. This adds to the conservatism in the calculated cumulative collective population impacts for both the workers and members of the general public at the site.

The above simplifying assumptions could result in some differences in the estimated cumulative impacts between this report and other site-specific documents. In addition, these simplifying assumptions and other assumptions used in performing calculations can result in some uncertainty regarding projected cumulative impacts. This cumulative impact analysis should be used only as a starting point for analyzing site-specific cylinder management program activities at the K-25 site; any future site-specific NEPA analysis would supersede this cumulative analysis.

5.2 IMPACTS OF CONTINUED CYLINDER STORAGE AND PREPARATION

This analysis focuses on potential cumulative impacts at the site from continued storage and cylinder preparation. For purposes of analysis, the maximum impacts estimated at the site for continued cylinder storage and cylinder preparation activities from any of the PEIS alternatives were used to provide an upper estimate of potential cumulative impacts.

This analysis considers all actions on ORR and is not limited to the K-25 site alone, except where specified. Aside from the continuation of existing operations and depleted UF_6 management activities, reasonably foreseeable future actions at ORR include waste management activities (DOE 1997a), stockpile stewardship and management activities (DOE 1996c), storage and disposition of weapons-usable fissile materials (DOE 1996d), the disposition of highly enriched uranium (DOE 1996e), interim storage of enriched uranium (DOE 1994b), the transfer of nonnuclear functions (DOE 1993), changes in the sanitary sludge land application program (DOE 1996f), proposed reindustrialization of the K-25 site as the East Tennessee Technology Park (DOE 1997b), and environmental restoration activities at the K-25 site (DOE 1997c). Many of these future actions would take place at the other two sites (Y-12 and ORNL) at ORR. However, because of the overlapping ROI, except for cases where available data preclude a reservationwide view, the cumulative impacts for K-25 generally include the impacts for ORR as a whole.

Table 5.1 identifies the projected cumulative impacts that would result from the two depleted UF_6 management activities that would occur at the K-25 site, existing activities, and planned actions described in the aforementioned EISs. The off-site MEI is specific to K-25. As identified in the table, annual radioactive releases would increase as a result of releases from the depleted UF_6 management activities, depleted UF_6 transport, and other possible actions associated with ORR. However, maximum cumulative radioactive releases would remain below the DOE dose limit of 100 mrem/yr to the off-site MEI.

The depleted UF_6 management options would result in very minimal additional land disturbance at the K-25 site; a maximum of about 7 additional acres (2.8 ha) for continued cylinder storage and 21 acres (8 ha) for cylinder preparation. The demand for water, wastewater, and power at ORR would not be greatly affected by depleted UF_6 activities that would occur at K-25. Cumulatively, water, wastewater, and power facilities at ORR would not require major improvements (expansions or upgrades) because projected cumulative future demand is less than existing capacities.

TABLE 5.1 Cumulative Impacts of Depleted UF_6 Activities, Existing Operations, and Other Reasonably Foreseeable Future Actions at Oak Ridge Reservation, 1999 through 2039

Impact Category	Impacts of Existing Operations[a]	Maximum Impacts of Depleted UF_6 Management Activities: Continued Storage[b]	Maximum Impacts of Depleted UF_6 Management Activities: Cylinder Preparation	Impacts of Other Reasonably Foreseeable Future Actions[c]	Cumulative Impacts[d]
Off-site population					
Collective dose, 41 years (person-rem)	1,763	0.34	0.002	21.4	1,780
Number of LCFs[e]	0.88	0.0004	1.0×10^{-6}	0.011	0.89
Annual dose to off-site MEI[f] (mrem)	9.82	0.46	3.0×10^{-5}	0.62	10.8
Worker population					
Collective dose, 41 years (person-rem)	2,788	200	480	3,400	6,880
Number of LCFs[g]	1.12	0.08	0.19	1.36	2.75
Transportation[h]					
Number of truck shipments, 41 years	42,640	–	4,732	70,834	118,206
Number of rail shipments, 41 years	328	–	1,183	26,000	27,511
Annual dose to MEI from truck (mrem)	4.2	–	0.0013	0.20	4.4
Annual dose to MEI from rail (mrem)	0.032	–	0.0009	0.068	0.10
Resources and infrastructure					
Land area (% of site)[i]	26.0	0.14	0.4	13.9	40.5
Water use (% capacity)	45.5	0.01	0.05	0.5	46.1
Wastewater production (% capacity)[j]	69.6	0.0	0.0	17.2	86.8
Power demand (% capacity)[j]	10.9	0.0	0.09	21.8	32.8
Air quality[k]	None	PM_{10}, HF	None	None	PM_{10}, HF
Groundwater quality[l]	24 parameters[m]	Uranium-238	None	6 parameters[n]	27 parameters[o]

[a] Includes impacts of current UF_6 management activities, waste management activities, and environmental restoration activities (at K-25) that have proceeded to a point where their consequences can be defined: Watershed I, Watershed II, Watershed III, Watershed IV, Watershed V, Watershed VI, and non-Watershed Areas (individual projects listed in DOE 1997c).

[b] The greater of either: (1) impacts from 41 years of continued storage under the No Action Alternative or (2) impacts from 20 years of continued storage under the Action Alternatives.

[c] These include impacts from EISs related to (1) stockpile stewardship and management (DOE 1996c), (2) storage and disposition of weapons-usable fissile materials (DOE 1996d), (3) disposition of surplus highly enriched uranium (DOE 1996e), (4) transfer of nonnuclear functions (DOE 1993), (5) waste management (DOE 1997a), (6) proposed changes in the sanitary sludge land application program (DOE 1996i), and (7) potential reindustrialization of the K-25 site (DOE 1997b). Impacts of reasonably foreseeable future actions do not include the potential environmental impacts of constructing and operating a proposed CERCLA waste management facility or the potential impacts of constructing and operating a barge facility, both of which will be estimated in the future at a time closer to the development of those two facilities (see DOE 1997b).

[d] Cumulative impacts equal the sum of the impacts of existing operations, depleted UF_6 management options, and other reasonably foreseeable future actions.

[e] Assumes 0.0005 LCF/person-rem.

[f] MEI at K-25. Based on LMES (1995a), which contains releases for the year 1994. Cumulative impacts assumes all facilities operate simultaneously and are located at the same point.

[g] Includes both facility and noninvolved workers. Assumes 0.0004 LCF/person-rem.

[h] The number of truck and rail shipments of radioactive materials. The MEIs (at gate) for truck and rail shipments were assumed to be different.

[i] Land area impacts are determined on the basis of the K-25 site area of 4,845 acres (1,961 ha) (including undeveloped sections) rather than the total ORR area of 34,516 acres (13,974 ha), since ORR consists of three main areas of activity separated by large tracts of a National Environmental Research Park that will largely remain undeveloped.

[j] Considers K-25 only.

[k] Impacts indicate which emissions would result in nonattainment. PM_{10} = particulate matter less than or equal to 10 :m in diameter.

[l] Existing groundwater quality impacts are for the K-25 site only. Impacts of depleted UF_6 management activities, environmental restoration activities, or other future actions indicate whether water quality could be affected.

[m] Antimony, arsenic, barium, benzene, cadmium, carbon tetrachloride, chloroform, chromium, 1,1-dichloroethene, 1,2-dichloroethene, fluoride, lead, methylene chloride, nickel, technetium-99, tetrachloroethene, thallium, toluene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, 1,1,2-trichloro-1,2,2-trifluoroethane, uranium, and vinyl chloride.

[n] 1,2-Dichloroethane, methylene chloride, plutonium-239, plutonium-240, technetium-99, and uranium-238.

[o] Only 27 parameters would be exceeded instead of 31 because methylene chloride, technetium-99, and uranium could be exceeded under existing operations, continued storage, and as a result of other future actions (i.e., they are included in more than one column).

Sources: LMES (1996a,b); DOE (1997a).

ORR is located in an attainment region where criteria air pollutants do not currently exceed regulatory standards. For construction activities at the K-25 site for continued storage or cylinder preparation, pollutant concentrations at the facility boundary would generally not exceed applicable air quality standards or guidelines. If short-term concentrations of fugitive dust emissions (PM_{10}) approached air quality standards during construction, these impacts would be temporary and could be minimized by good engineering and construction practices and standard dust suppression methods.

If current cylinder maintenance programs control continued cylinder corrosion, the air analysis indicates that the maximum HF concentration at the site boundary could reach a maximum of 23% of the standard. However, if no credit is taken for control of corrosion, the HF concentration could approach the primary standard concentration of 29 μg/m^3 (24-hour average) around the year 2020.

On the basis of data from 1994 and 1995 annual groundwater monitoring, 23 pollutants have been found to exceed primary drinking water regulation levels in groundwater at the K-25 site: antimony, arsenic, barium, cadmium, chromium, fluoride, lead, nickel, thallium, uranium (as estimated from gross alpha levels), benzene, carbon tetrachloride, chloroform, 1,1,-dichloroethene, 1,2-dichloroethene, methylene chloride, tetrachloroethene, toluene, 1,1,2-trichloro-1,2,2-trifluoroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, and vinyl chloride (LMES 1995a; 1996b). Gross beta levels (possibly indicative of technetium-99) also exceeded the standard. Another six pollutants could affect groundwater quality as a result of reasonably foreseeable future actions; these are 1,2-dichloroethane, methylene chloride, plutonium-239, plutonium-240, technetium-99, and uranium-238.

During continued storage of depleted UF_6, releases from breached cylinders could result in increased concentrations of uranium in the groundwater. If current cylinder maintenance programs control continued cylinder corrosion, the groundwater analysis indicates that the maximum uranium concentration in groundwater (from cylinder breaches) would be 7 μg/L, considerably below the 20 μg/L guideline level used for comparison (EPA 1996). If no credit is taken for reduced cylinder corrosion rates from painting and maintenance, cylinders would have to undergo uncontrolled corrosion until about 2025 before groundwater concentrations of uranium would approach 20 μg/L in the future. The groundwater concentration would not actually reach 20 μg/L until later than the year 2100.

6 BIBLIOGRAPHY

Allison, T., 1996, "Baseline Unemployment Statistics," intra-laboratory memorandum from T. Allison to H. Avci (Argonne National Laboratory, Argonne, Ill.), Oct. 23.

Allison, T., and S. Folga, 1997, *Socioeconomic Impact Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from T. Allison and S. Folga (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

ANL: see Argonne National Laboratory.

Argonne National Laboratory, 1991, *Environmental Site Description for a Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) Production Plant at the Oak Ridge Gaseous Diffusion Plant Site*, ANL/EAIS/TM-58, prepared by Argonne National Laboratory, Argonne, Ill., for U.S. Department of Energy, Office of Nuclear Energy, Sept.

BEA: see U.S. Bureau of Economic Analysis.

Cash, J.M., 1996, facsimile transmittal, with attachments, from J.M. Cash (Three-Site UF_6 Cylinder Management Program, Lockheed Martin Research Corp., Oak Ridge National Laboratory, Oak Ridge, Tenn.) to H.M. Hartmann (Argonne National Laboratory, Argonne, Ill.), Oct. 4.

Charles, L.D., et al., 1991, *Cost Study for the D&D of the GDPs: Depleted Uranium Management and Conversion,* K/D-5940-F, Martin Marietta Energy Systems, Oak Ridge, Tenn.

Cheng, J.-J., et al., 1997, *Human Health Impact Analyses for Normal Operations in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from J.-J. Cheng (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

Conley, J., 1996, "Total VOC & NOX Emissions for Roane and Anderson Bounties," memorandum (facsimile transmittal) from J. Conley (Tennessee Division of Air Pollution Control, Knoxville, Tenn.) to M. Monarch (Argonne National Laboratory, Argonne, Ill.), Dec. 6.

DOE: see U.S. Department of Energy.

EPA: see U.S. Environmental Protection Agency.

Fielder, G.F., Jr., 1974, *Archaeological Survey with Emphasis on Prehistoric Sites of the Oak Ridge Reservation, Oak Ridge, Tennessee*, ORNL/TM-4694, Oak Ridge National Laboratory, Oak Ridge, Tenn., Oct.

Folga, S., 1996a, "Information Requested Concerning the Transfer Facility," cc:mail transmittal from S. Folga (Argonne National Laboratory, Argonne, Ill.) to D. Tomasko et al. (Argonne National Laboratory, Argonne, Ill.), Nov. 7.

Folga, S., 1996b, "Scaling Approach for the Cylinder Treatment and Overpack," cc:mail transmittal from S. Folga (Argonne National Laboratory, Argonne Ill.) to H. Avci et al. (Argonne National Laboratory, Argonne, Ill.), May 9.

Folga, S., 1996c, "Total Workforce for the Overpack Concept in the DUF_6 PEIS," cc:mail transmittal from S. Folga (Argonne National Laboratory, Argonne, Ill.) to H. Hartmann et al. (Argonne National Laboratory, Argonne, Ill.), Nov. 5.

Folga, S., 1996d, "Updated Information for the Long-Term Storage of UF_6 in Cylinder Yards Option in the DUF_6 PEIS," memorandum from S. Folga (Argonne National Laboratory, Argonne, Ill.) to DUF_6 PEIS Impacts Team (Argonne National Laboratory, Argonne, Ill.), Oct. 29.

Geraghty & Miller, Inc., 1989, *Hydrogeology of the Oak Ridge Gaseous Diffusion Plant,* Revised Draft Report, prepared by Geraghty & Miller, Inc., Oak Ridge, Tenn., for Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., Dec.

Hodges, J., 1996, "Average Exposure Data for Cylinder Yard Workers," attachment to facsimile transmittal from J. Hodges (Paducah Gaseous Diffusion Plant, Paducah, Ky.) to C.E. Bradley (U.S. Department of Energy, Washington, D.C.), Jan. 23.

Hogan, D., 1996, "Emissions Inventory System: Plant Actual Emissions in Tons per Year," facsimile transmittal from D. Hogan (Kentucky Division of Air Quality, Frankfort, Ky.) to M. Monarch (Argonne National Laboratory, Argonne, Ill.), Dec. 5.

Lawrence Livermore National Laboratory, 1997, *Depleted Uranium Hexafluoride Management Program; the Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride*, UCRL-AR-124080, Volumes I and II, prepared by Lawrence Livermore National Laboratory, Science Applications International Corporation, Bechtel, and Lockheed Martin Energy Systems for U.S. Department of Energy.

LLNL: see Lawrence Livermore National Laboratory.

LMES: see Lockheed Martin Energy Systems, Inc.

Lockheed Martin Energy Systems, Inc., 1995a, *Oak Ridge Reservation Annual Site Environmental Report for 1994*, ES/ESH-57, prepared by Environmental, Safety, and Health Compliance and Environmental Management staffs, Oak Ridge Y-12 Plant, Oak Ridge National Laboratory, and Oak Ridge K-25 Site, Oak Ridge, Tenn., for U.S. Department of Energy, Oct.

Lockheed Martin Energy Systems, Inc., 1995b, *Oak Ridge Reservation Annual Site Environmental Report Summary for 1994*, ES/ESH-58, prepared by Environmental, Safety, and Health Compliance and Environmental Management, Oak Ridge Y-12 Plant, Oak Ridge National Laboratory, and Oak Ridge K-25 Site, Oak Ridge, Tenn., for U.S. Department of Energy, Sept.

Lockheed Martin Energy Systems, Inc., 1996a, *Environmental Monitoring and Surveillance on the Oak Ridge Reservation: 1994 Data*, ES/ESH-59, prepared by Environmental, Safety, and Health Compliance and Environmental Management staffs, Oak Ridge Y-12 Plant, Oak Ridge National Laboratory, and Oak Ridge K-25 Site, Oak Ridge, Tenn., for U.S. Department of Energy, April.

Lockheed Martin Energy Systems, Inc., 1996b, *Oak Ridge Reservation Annual Site Environmental Report for 1995*, ES/ESH-69, prepared by Oak Ridge National Laboratory, Oak Ridge, Tenn., the Oak Ridge Y-12 Plant, and the Oak Ridge K-25 Site, for the U.S. Department of Energy, Sept.

Lockheed Martin Energy Systems, Inc., 1997a, *K-25 Site UF_6 Cylinder Storage Yards Final Safety Analysis Report*, K/D-SAR-29, prepared for the U.S. Department of Energy, Feb. 28.

Lockheed Martin Energy Systems, Inc., 1997b, *Oak Ridge Reservation Annual Site Environmental Report for 1996,* ES/ESH-73, prepared by Oak Ridge National Laboratory, Oak Ridge Y-12 Plant, and East Tennessee Technology Park, Oak Ridge, Tenn., for U.S. Department of Energy, Oct.

Lockheed Martin Energy Systems, Inc., 1997c, *K-25 Site UF_6 Cylinder Storage Yards Final Safety Analysis Report,* K/D-SAR-29, Oak Ridge, Tenn., Feb.

Lockheed Martin Energy Systems, Inc., 1997d, *UF_6 Cylinder Project Management Plan*, K/TSO-30, Rev. 2, prepared by Project Support Organization, East Tennessee Technology Park, Oak Ridge, Tenn., for U.S. Department of Energy, July.

Lockheed Martin Energy Systems, Inc., 1997e, *Safety Analysis Report, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-174, Vols. 1 and 2, prepared for U.S. Department of Energy, Jan.

Lockheed Martin Energy Systems, Inc., 1997f, *Safety Analysis Report, Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, POEF-LMES-89, Rev. RO-A, prepared for U.S. Department of Energy, Jan.

Lyon, B.F., 1996, "Materials Required for PEIS," memorandum from B.F. Lyon (Oak Ridge National Laboratory, Oak Ridge, Tenn.) to J.M. Cash (Lockheed Marietta Energy Research Corporation, Oak Ridge, Tenn.), Nov. 20.

Lyon, B.F., 1997, E-mail transmittal from B.F. Lyon (Oak Ridge National Laboratory, Oak Ridge, Tenn.) to H. Hartmann (Argonne National Laboratory, Argonne, Ill.), March 4 (with correction, March 19).

Martin Marietta Energy Systems, Inc., 1994a, *Oak Ridge Reservation, Annual Site Environmental Report for 1993*, ES/ESH-47, prepared by Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., for U.S. Department of Energy, Nov.

Martin Marietta Energy Systems, Inc., 1994b, *Technical Site Information, The Oak Ridge K-25 Site*, K/EN/SFP-11, prepared for U.S. Department of Energy, Oak Ridge, Tenn., July.

McGuire, S.A., 1985, *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees*, NUREG-1140, Draft Report for Comment, U.S. Nuclear Regulatory Commission, Washington, D.C., June.

MMES: see Martin Marietta Energy Systems, Inc.

National Council on Radiation Protection and Measurements, 1987, *Ionizing Radiation Exposures of the Population of the United States*, NCRP Report No. 93, Bethesda, Md.

National Safety Council, 1995, *Accident Facts*, 1995 ed., Itasca, Ill.

NCRP: see National Council on Radiation Protection and Measurements.

Nieves, L.A., et al., 1997, "Analysis of Options for Disposition of Empty Depleted UF_6 Cylinders," attachment to memorandum from L.A. Nieves et al. (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

NRC: see U.S. Nuclear Regulatory Commission.

Parks, J.W., 1997, "Data for Revised No Action Alternative in the Depleted UF_6 Programmatic Environmental Impact Statement," memorandum from J.W. Parks (Assistant Manager for Enrichment Facilities, EF-20, U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tenn.) to C.E. Bradley (U.S. Department of Energy, Office of Facilities, NE-40, Germantown, Md.), April 7.

Pawel, S.J., 1997, "Technical Basis for Cylinder Painting Schedule" (letter report ORNL/CST-SP-021097-06), attachment to memorandum from S.J. Pawel (Oak Ridge National Laboratory, Oak Ridge, Tenn.) to M.S. Taylor et al. (Oak Ridge National Laboratory, Oak Ridge, Tenn.), Feb. 10.

Policastro, A.J., et al., 1997, *Facility Accident Impact Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from A.J. Policastro (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), June 15.

Rothschild, E.R., et al., 1984, *Resource Management Plan, Oak Ridge Reservation, Volume 10, Appendix J: Hydrology*, ORNL-6026/V10, Oak Ridge, Tenn., July.

Standard & Poor's, 1996, *Industry Surveys, Metals: Industrial*, McGraw-Hill Book Co., New York, N.Y., Nov. 21, p. 1.

Tomasko, D., 1997a, *Threshold Surface Water Runoff Calculations for the No Action Alternative in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from D. Tomasko (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

Tomasko, D., 1997b, *Water and Soil Impact Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from D. Tomasko (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill., May 21.

Tschanz, J., 1997a, *Air Impact Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from J. Tschanz (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

Tschanz, J., 1997b, *Bounding Case HF Concentrations for the No Action Alternative*, memorandum from J. Tschanz (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), April 16.

U.S. Bureau of the Census, 1992a, *1990 Census of Population and Housing,* Summary File Tape 1 on CD-ROM (machine-readable data files), U.S. Department of Commerce, Washington, D.C.

U.S. Bureau of the Census, 1992b, *1990 Census of Population and Housing,* Summary File Tape 3 on CD-ROM (machine-readable data files), U.S. Department of Commerce, Washington, D.C.

U.S. Bureau of the Census, 1994, *County and City Data Book, 1994*, 12th ed., Economics and Statistics Administration, Washington, D.C., Aug., pp. 149–150, 219–220, 233–234, 429–430, 443–444, 499–500, 513–514.

U.S. Bureau of the Census, 1996, *Statistical Abstract of the United States: 1996*, 116th ed., Washington, D.C., p. 750.

U.S. Bureau of Economic Analysis, 1996, *Tennessee County Projections to 2040*, U.S. Department of Commerce, Regional Economic Analysis Division, Washington, D.C.

U.S. Department of Commerce, 1997, *Statistical Abstract of the United States,* 117th edition, Economic and Statistics Administration, Oct.

U.S. Department of Commerce, 1999, *U.S. Census Bureau, Annual Survey of Manufactures, Geographic Area Statistics,* http://www.census.gov/prod/www/abs/geograph.html.

U.S. Department of Energy, 1979, *Environmental Assessment of the Oak Ridge Gaseous Diffusion Plant Site*, DOE/EA-0106, Oak Ridge, Tenn., Dec.

U.S. Department of Energy, 1992, *Radiological Control Manual*, DOE/EH-0256T, Assistant Secretary for Environment, Safety and Health, Washington, D.C., June.

U.S. Department of Energy, 1993, *Nonnuclear Consolidation, Environmental Assessment, Volume I: Nuclear Weapons Complex Reconfiguration Program*, DOE/EA-0792, Office of Defense Programs, Washington, D.C., June.

U.S. Department of Energy, 1994a, *DNFSB Technical Review of UF_6 Cylinder Management, Oak Ridge K-25 Site*, Dec. 13–14.

U.S. Department of Energy, 1994b, *Proposed Interim Storage of Enriched Uranium above the Maximum Historical Storage Level at the Y-12 Plant, Oak Ridge, Tennessee*, DOE/EA-0929.

U.S. Department of Energy, 1995a, *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement; Volume 1, Appendix F: Nevada Test Site and Oak Ridge Reservation Spent Nuclear Fuel Management Programs*, DOE/EIS-0203-F, Idaho Operations Office, Idaho Falls, Idaho, April, Appendix F, Sections 4.6 and 4.13.

U.S. Department of Energy, 1995b, *Integrated Data Base Report — 1994: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics,* DOE/RW-0006, Rev. 11, prepared by Oak Ridge National Laboratory, Oak Ridge, Tenn., for U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Washington, D.C., Sept.

U.S. Department of Energy, 1995c, *Mixed Waste Inventory Summary Report,* DOE/M96-GT-029, Washington, D.C.

U.S. Department of Energy, 1996a, *Technical Report on Affected Environment for the DOE Sites Considered in the DOE Waste Management Programmatic Environmental Impact Statement (WM PEIS),* Volumes I and II, META/Berger-SR-01, prepared by META/Berger, Gaithersburg, Md., for U.S. Department of Energy, Office of Environmental Management, Dec.

U.S. Department of Energy, 1996b, *Refurbishment of Uranium Hexafluoride Cylinder Storage Yards C-745-K, L, M, N, and P and Construction of a New Uranium Hexafluoride Cylinder Storage Yard (C-745-T) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Environmental Assessment*, DOE/EA/1118, Oak Ridge Operations Office, Oak Ridge, Tenn., July.

U.S. Department of Energy, 1996c, *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*, DOE/EIS-0236, Washington, D.C., Sept.

U.S. Department of Energy, 1996d, *Storage and Disposition of Weapons-Usable Fissile Materials, Final Programmatic Environmental Impact Statement*, DOE/EIS-0229, Washington, D.C., Dec.

U.S. Department of Energy, 1996e, *Disposition of Surplus Highly Enriched Uranium, Final Environmental Impact Statement*, DOE/EIS-0240, Office of Fissile Materials Disposition, Washington, D.C., June.

U.S. Department of Energy, 1996f, *Environmental Assessment, Proposed Changes to the Sanitary Sludge Land Application Program on the Oak Ridge Reservation*, DOE/EA-1042, Oak Ridge Operations Office, Oak Ridge, Tenn.

U.S. Department of Energy, 1997a, *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*, DOE/EIS-0200-F, Office of Environmental Management, Washington, D.C., May.

U.S. Department of Energy, 1997b, *Final Environmental Assessment for the Lease of Land and Facilities within the East Tennessee Technology Park, Oak Ridge, Tennessee,* DOE/EA-1175, Oak Ridge Operations Office, Oak Ridge, Tenn.

U.S. Department of Energy, 1997c, *East Tennessee Technology Park Site-Wide Remedial Investigation Work Plan, Oak Ridge, Tennessee*, Volume 1, Chapters 1–6, Office of Environmental Management, Oak Ridge Operations Office, Oak Ridge, Tenn.

U.S. Department of Energy, 1999a, *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride,* DOE/EIS-0269, Office of Nuclear Energy, Science and Technology, Apr.

U.S. Department of Energy, 1999b, *Record of Decision for Long-Term Management and Use of Depleted Uranium Hexafluoride,* Office of Nuclear Energy, Science and Technology, July.

U.S. Environmental Protection Agency, 1995, *Risk-Based Concentration Table, July–December 1995*, Region III, Hazardous Waste Management Division, Office of Superfund Programs, Philadelphia, Pa., Oct.

U.S. Environmental Protection Agency, 1996, *Drinking Water Regulations and Health Advisories*, EPA 882-B-96-002, Office of Water, Washington, D.C., Oct., pp. 1–11.

U.S. Nuclear Regulatory Commission, 1994, "10 CFR Part 19, et al., Certification of Gaseous Diffusion Plants; Final Rule," discussion on Section 76.85, "Assessment of Accidents," *Federal Register* 59(184):48954–48955, Sept. 23.